POWER

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SOOT

BY RUFUS T. STROHM

WHENEVER the gas from the fuel distills,
The soot sets the furnace to belching and smoking;
It sticks to the face of the brickwork and fills
The length of the tubes till they're cluttered and choking;
It clings to the shell just as close as the brother
Who wants you to lend him a dollar or two,
Producing a blanket that threatens to smother
The heat that is trying its best to get through.

A COATING of soot on the shell in a test
Plays hob with the figures in spite of our scheming;
It knocks the efficiency all galley west
And gives an outlandishly low rate of steaming.
The boss sees the record and grows apoplectic
And calls us a parcel of lazy galoots,
And swears in a manner unvarnished and hectic,
While all of us cower and shake in our boots.

A LOT OF IT floats to the top of the stack,
Dispersing its flecks through the outlying places,
And quietly paints with indelible black
Amazing designs on pedestrians' faces;
And then, in a huff, they present a petition
In which they politely but urgently pray
The law to enforce the complete abolition
Of soot and of smoke with the smallest delay.

THE WASHINGS that hang for an hour or so
Wherever those fluttering atoms can spot 'em
Are changed from the beautiful whiteness of snow
To shades that outrival the teakettle's bottom,
And housewives troop into the office by legions,
With war on their faces and blood in their eyes,
Consigning us all to the nethermost regions
In language so hot that it sizzles and fries.

WE HATE IT because it increases the waste
And gives the boss reason for worthy profaneness,
And also because it is not to our taste
To have women curse us with feminine plainness;
But here is a secret—our hate is the keener,
Because of the beggarly trick that it plays;
We've got to remove it with steam lance or cleaner
On even the hottest of midsummer days!

New Boilers for Ashley Street Station

By JOHN HUNTER
Chief Engineer, Union Electric Light and Power Company

To supply an additional generating capacity of 60,000 kw., 28 Scotch marine and small water-tube boilers on the first floor of a double-deck boiler plant will be replaced by 24 high-duty water-tube boilers while maintaining operation in the balance of the plant. Ten boilers have been installed and equipped with economizers, underfeed stokers and forced and induced draft. This unusual choice of stoker for a low-grade Illinois coal has resulted in an over-all boiler and furnace efficiency of 74.5 per cent.

TO install the additional boiler capacity for driving the new 25,000-kv.-a. turbines now being installed in the Ashley Street Station of the Union Electric Light and Power Co. necessitated the making of extensive changes in the boiler-plant building and equipment. Prior to the installation of the new turbines, the station generating capacity was 68,000 kw., steam being generated in fifty-two 508-hp. boilers equipped with chain grates operating on natural draft. The maximum continuous rating obtainable from these boilers was sufficient for the generation of approximately 52,000 kw. at the switchboard. To supply steam for an additional 60,000 kw. of station capacity called for the rearrangement of the building and equipment in such a manner as to more than double the boiler-plant capacity.

The boiler plant of Ashley Street Station is built on two floors or decks. The upper-deck boilers, of which there are 34, occupy the space directly below the overhead coal bunkers and are so located as to their clearances that any increase in size or rearrangement of stoker or furnace equipment for the purpose of increasing capacity is not feasible. Consequently all changes leading to increased capacity have been confined to the lower-deck boiler room. Here were originally installed 28 Scotch marine boilers with internally fired furnaces, whose operation had not been a success owing to their being ill-suited to the burning of the low-

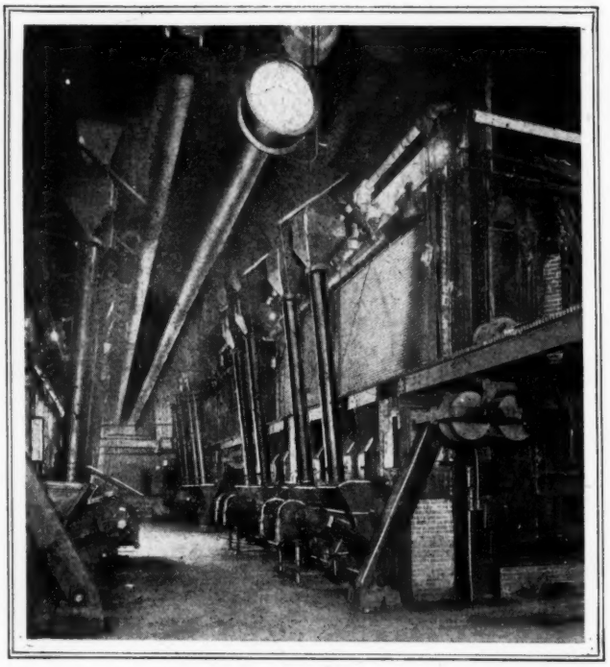


FIG. 1. FIRST INSTALLATION OF TEN EDGE MOOR BOILERS AND WESTINGHOUSE UNDERFEED STOKERS

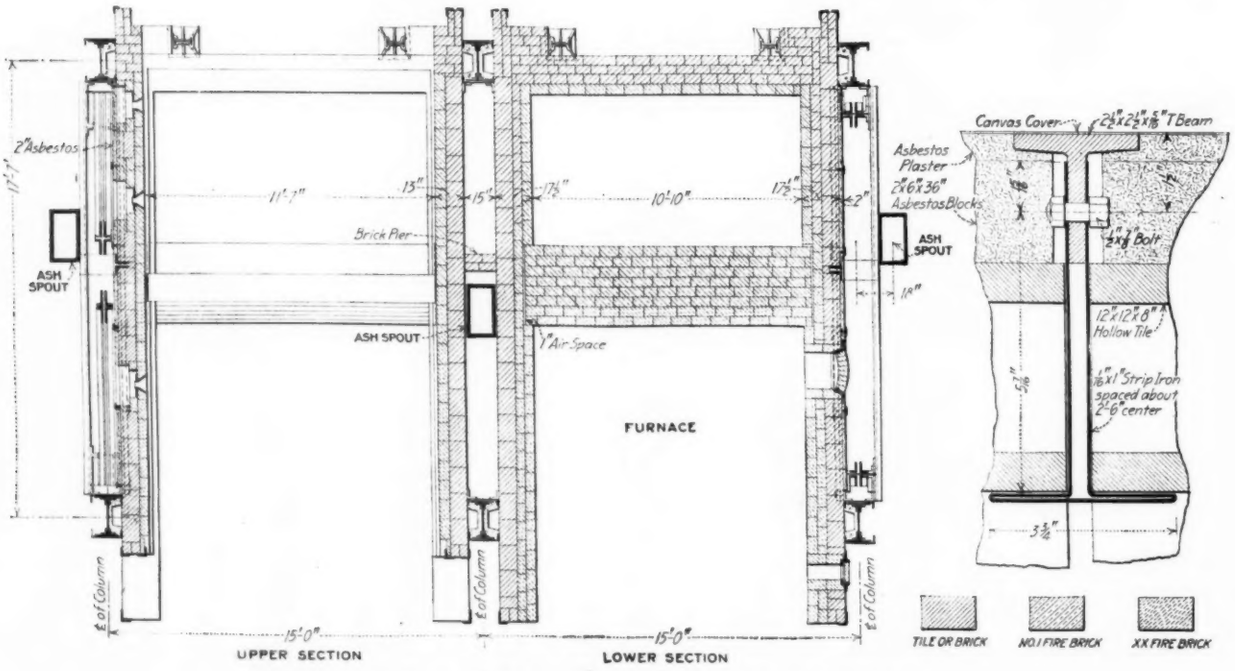


FIG. 2. SECTIONAL PLAN OF BOILER SETTING AND CROSS-BRACING

grade Western coals which must of necessity be utilized in the St. Louis district. These units had already been abandoned and a portion of them replaced by water-tube boilers with chain-grate stokers. The elevation of the floor of this lower-deck boiler room was such that it was entirely feasible to remove the old boilers and install new boiler equipment upon a floor built 3 ft. lower than the old one, thus permitting an increase of 3 ft. in the height of the furnaces; that is, 10 ft. from the floor to the bottom of the front header instead of 7 feet. The consensus of opinion in respect to the obtaining of boiler capacities greatly in excess of rating indicates that there should be at least 10 ft. of elevation at this point if complete combustion is to be obtained. Consequently, it was decided to remove all the boilers in this portion of the plant and rearrange the structural work so as to install in their place twenty-four 558-hp. Edge Moor boilers equipped with economizers, underfeed stokers and forced and induced draft.

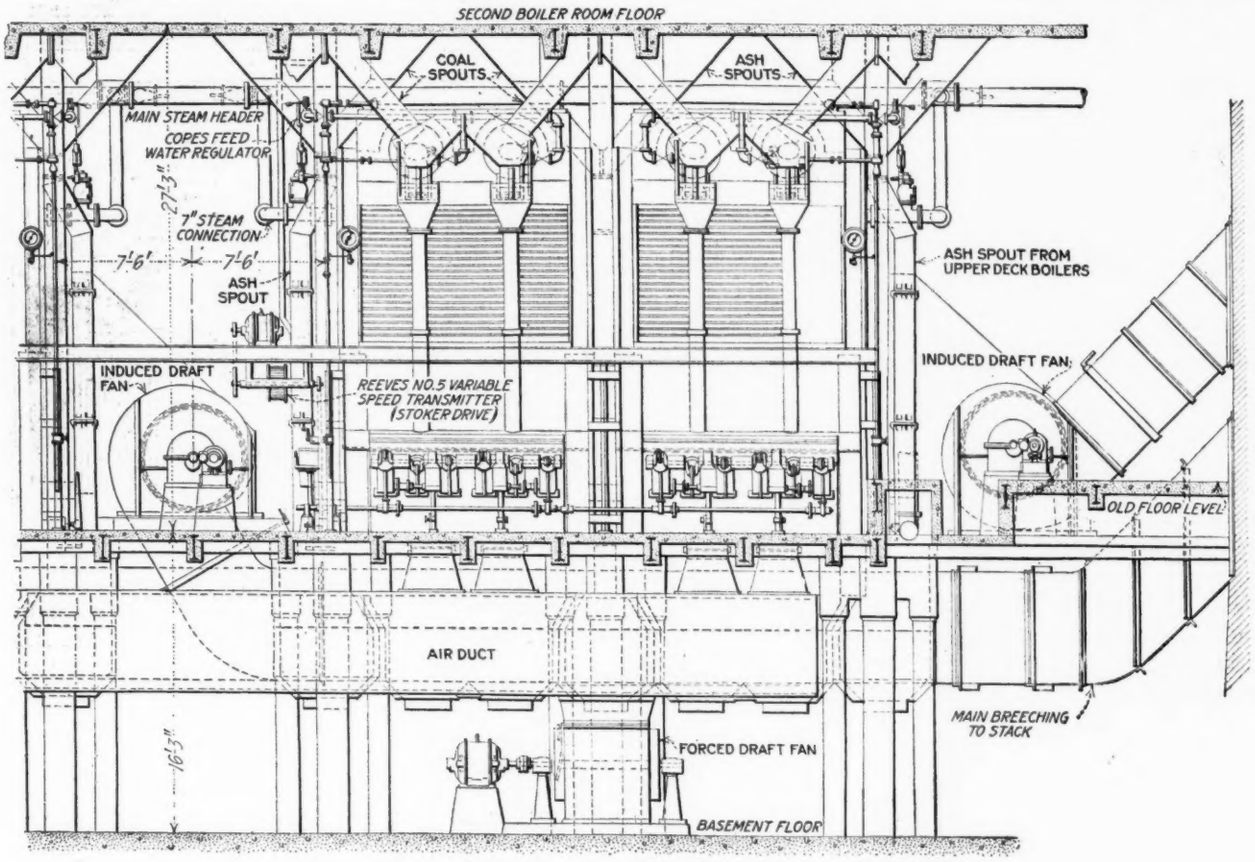


FIG. 3. TYPICAL FRONT ELEVATION OF BATTERY OF BOILERS

The primary installation of ten of these boilers, shown in Fig. 1, was completed in 1916 and put into service early in 1917 with the completion of the first of the three 25,000-kv.-a. turbines. With the increased head room made available through the lowering of the general floor level, it was possible to install a somewhat larger boiler than the water-tube boilers already located in the station. Consequently, the new units are 16 tubes high instead of 14 as in the case of the upper-deck boilers. The fact that each of these boilers is good for 3000 kw. on the switchboard indicates the successful results being obtained with the new arrangement. The upper-deck boilers, which operate at 185 lb. steam pressure, will be reserved exclusively for driving the old 12,000-kw. turbines, whereas the entire lower-deck boiler room, operating at 225 lb. steam pressure, will furnish steam for the new 25,000-kv.-a. turbines.

Structural work in connection with the preparation for the installation of these boilers was extensive. Clearances for the side walls were such that it was found necessary to remodel the cross-bracing of the boiler house in such a manner that while maintaining its original strength, it should occupy about one-third of the space. This was accomplished as shown in Fig. 2, through the rearrangement of the structural shapes of which these building braces were made. The taking out of the steelwork in an entire floor was precarious, inasmuch as the main building columns supported not only the entire upper-deck boiler house, but also the overhead bunkers having a capacity of 13,200 tons of coal. In removing the lower-deck floor steel, the main building columns would be left temporarily unsupported for 40 ft. of their length. It was therefore found necessary to temporarily brace all the building columns in such a manner that there would be no possibility of lateral deflection due to the heavy weights supported. Telegraph poles were used for the purpose, these being cut approximately to the length of the steel removed and tightly wedged into place.

Throughout the entire work of remodeling this boiler room it was essential first of all that the equipment on the upper deck be continued in regular operation without interruption. This involved the careful manipulation of steam and feed-water headers and numerous

other piping systems when changes were being made. Such work necessitated a great many "cut overs" which could be accomplished only during the hours that the station load was low, for the most part on Saturday nights and Sundays. However, all such work in connection with the installation of the ten boilers was successfully carried out without any interruption of the regular service of the plant.

The Edge Moor boilers, Figs. 3 and 4, which were decided upon for this installation, are equipped with Westinghouse underfeed stokers, Foster superheaters and Sturtevant economizers. The Foster superheaters are located at the top of the first and second pass of the boiler and give a superheat of 150 deg. The boilers themselves are built up with the unique side-wall construction shown in Fig. 5. These walls, which have the usual firebrick lining 9 in. thick opposite the furnace proper, are backed up with hollow building tile 8 in. thick bonded in with common red brick. On the outside of the tile is placed 2 in. of air-cell covering securely fastened and cemented in place, then covered with canvas. On the outside of the building tile and beneath the 2-in. covering is placed a coating of "boiler seal," the object of this being to stop up cracks and prevent air leakage through the setting. Six months' operation of the boilers has proved that these settings are entirely satisfactory.

The installation of underfeed stokers in a power station that must of necessity use low-grade Illinois coal was a new and somewhat radical departure. Heretofore there had been no extensive installations where fuel of this character had been burned, and there was little encouragement from any source outside of the manufacturer, that successful operation could be obtained with this coal on this equipment. However, after six months of operation the success of the venture has been proved beyond a doubt. Boiler ratings up to 200 per cent. are being carried continuously with an over-all boiler and furnace efficiency of 74.5 per cent.—this, as opposed to approximately 65 per cent. which was the maximum obtainable efficiency from the chain-grate stokers.

The forced-draft equipment used to serve these boilers was built by the Buffalo Forge Co. The blowers are driven by 100-hp. Westinghouse motors and are capable of delivering 40,000 cu.ft. of air per minute. With their flexible arrangement of air ducts the blowers are located in the basement immediately below the center of the boiler room (see Fig. 6) and receive their air in large measure from the ventilating ducts of the 25,000-kv.-a. turbines which discharge air at the rate of 60,000 cu.ft. per min. into the boiler-room basement.

Consisting of a series of hoppers shown in Fig. 8, the new ash-handling equipment for both upper- and lower-deck boilers is also located in the basement, but in adjacent areaways and separated from the forced-draft equipment by tile partitions. One of the important considerations in connection with the rebuilding of the ash hoppers was the fact that the underfeed stokers burning low-grade coal would make clinkers of too large

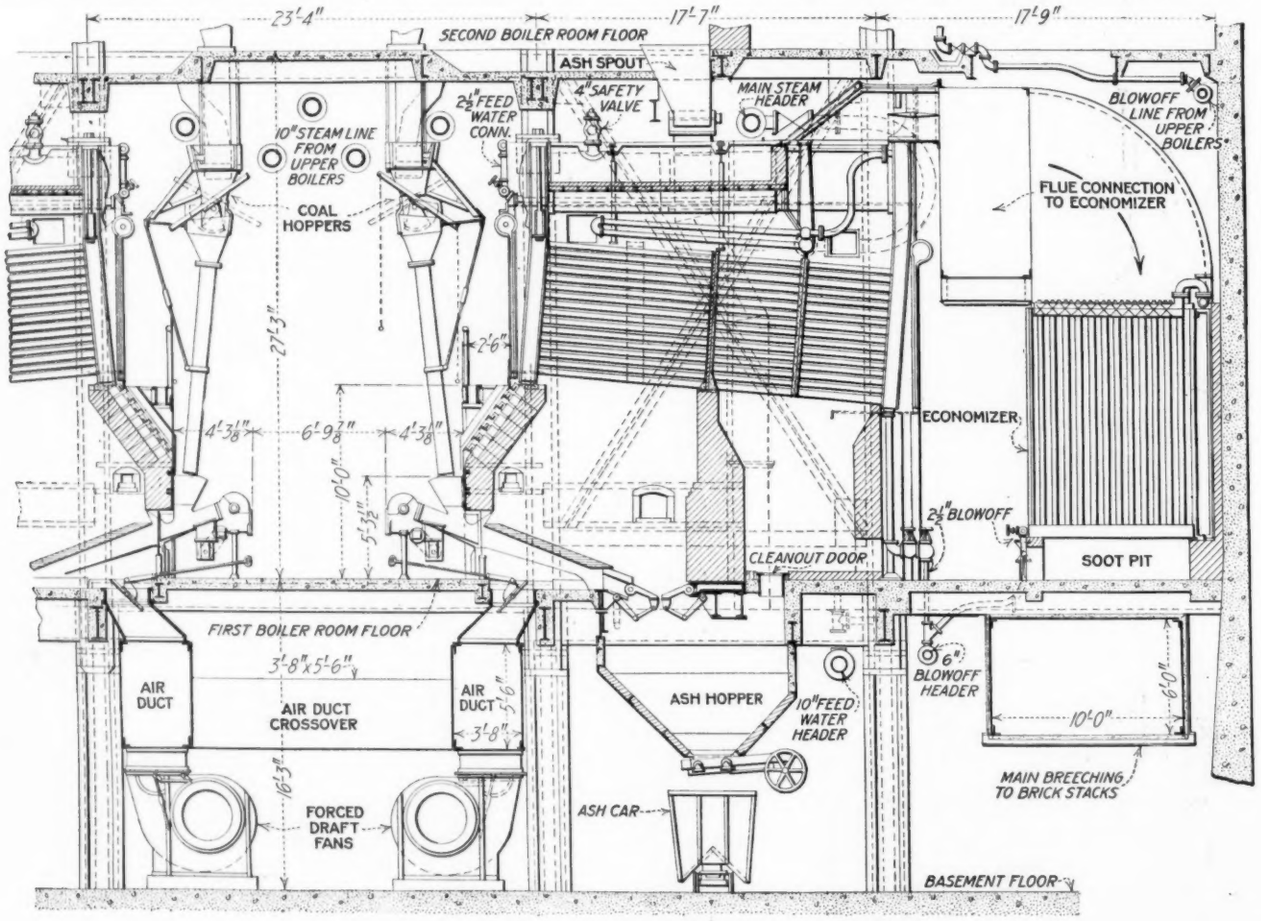


FIG. 4. SECTIONAL SIDE ELEVATION OF BOILERS

size to pass through the openings in the ash hoppers serving the chain-grate installation. Consequently the new ash hoppers were equipped with 24 x 30-in. cast-steel sliding doors located across the bottom and driven by rack and pinion. The ashes fall by gravity from the

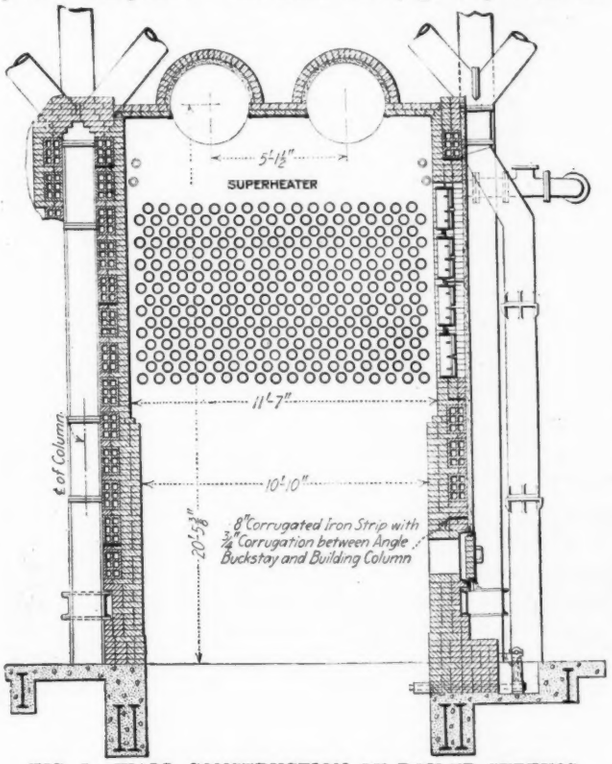


FIG. 5. WALL CONSTRUCTION OF BOILER SETTING

hoppers into three-ton receiving cars driven by storage-battery locomotives, thence are delivered to a skip hoist from which they are discharged into the receiving ash bunker. A second ash bunker is to be placed outside of the building and will also be arranged to deliver ashes to railroad cars placed underneath.

Fig. 9 shows the Sturtevant economizers and induced-draft equipment for the new boiler units. Each economizer is arranged to receive the outgoing gases from a battery of two boilers. The induced-draft fans are driven by 56-hp. high-speed Kerr turbines shown in Fig. 7. The Westinghouse stokers are driven by 15-hp. Westinghouse motors whose speed is controlled by a Reeves variable transmission drive. These drives are working out successfully and give a range of speed of from 10 to 60 strokes of the ram per hour.

Precision "3 in 1" air gages, such as shown in Fig. 10, are used for indicating draft pressures in the blow-

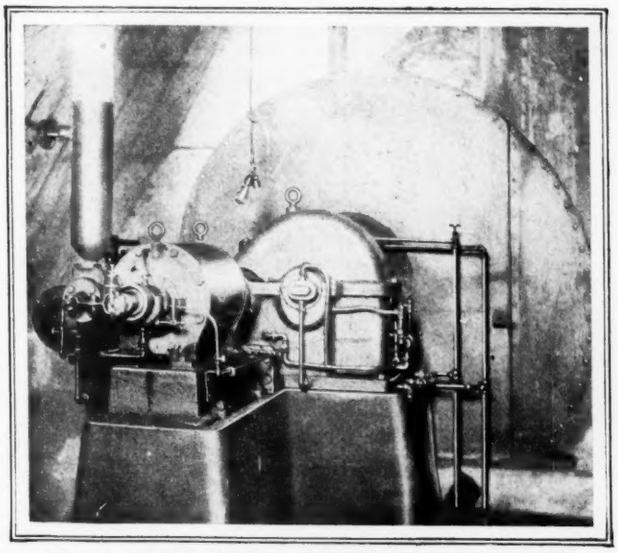


FIG. 7. STURTEVANT INDUCED-DRAFT FAN AND KERR TURBINE

ers, furnaces and uptakes. The average draft in the uptake is 1¼ in. of water, with that in the furnace slightly below atmospheric pressure, while the available force of the air blast is 4 in. With this equipment it is possible to obtain ratings in excess of 300 per cent. for periods of one hour or slightly longer. On the economizers are "Tycos" double pen recording thermometers for incoming and outgoing water temperatures. Each boiler is also equipped with a General Electric indicating flow meter calibrated to read directly in hundreds of boiler horsepower. With these instru-

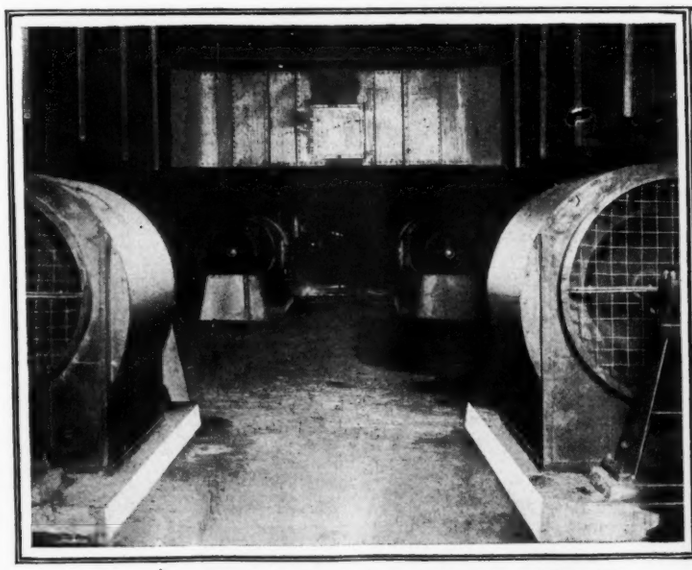


FIG. 6. FORCED-DRAFT FANS AND AIR DUCTS IN BASEMENT, BELOW BOILER ROOM

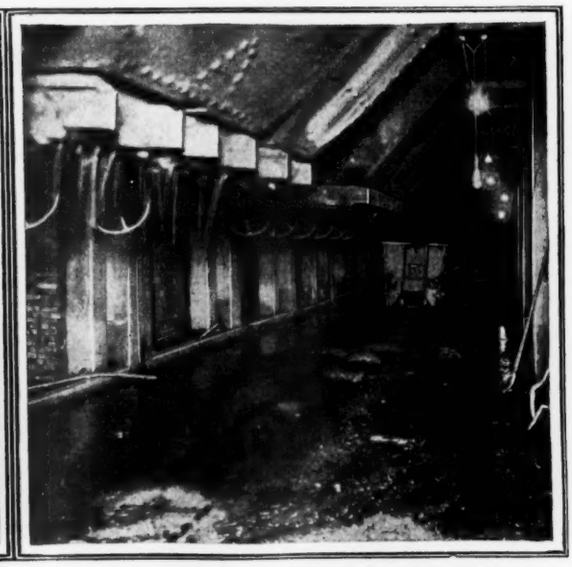


FIG. 8. ASH HOPPERS AND THREE-TON INDUSTRIAL CAR

ments it is possible to obtain accurately all the essential information in connection with the operation of the boilers and stokers.

Centrifugal pumps feed the new boilers, the water supply coming from Hoppes feed-water heaters. A temperature of approximately 130 deg. is maintained at the economizer inlets, and the increase in temperature through the economizers is about 100 degrees.

To complete the boiler requirements necessary for the new turbine installation, there are being installed this year three additional batteries of two boilers each similar to those described. This will complete the installation of 16 of the 24 high-capacity boilers that will completely fill the space available in the lower-deck boiler plant. The remaining four batteries will be equipped with Riley stokers and will be installed in 1918. This will give an aggregate of 13,392 boiler horsepower to serve turbines rated at 60,000 kw., a ratio of 1 to 4½.

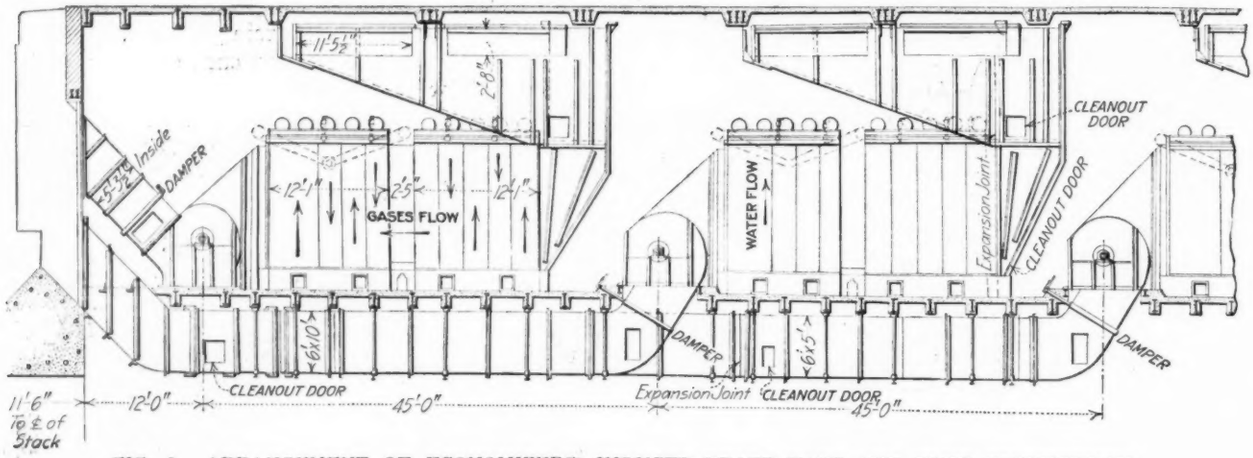


FIG. 9. ARRANGEMENT OF ECONOMIZERS, INDUCED-DRAFT FANS AND FLUE CONNECTIONS

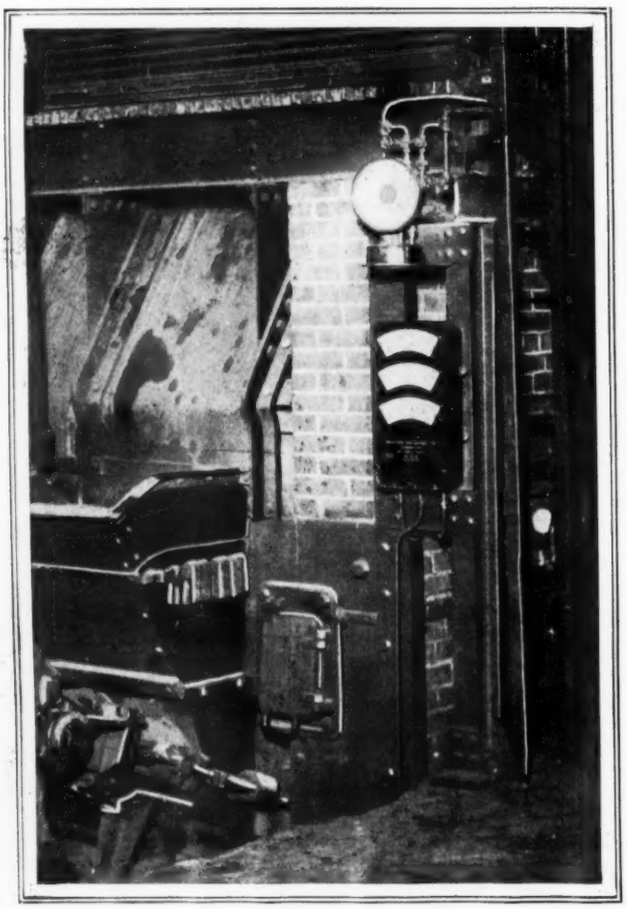


FIG. 10. DRAFT GAGES AND STEAM-FLOW METER CONVENIENTLY LOCATED

To obtain the highest efficiency and maximum capacity from the new boiler and turbine installation, it was deemed advisable to increase the operating steam pressure of the station from 185 to 225 lb. This involves some complication inasmuch as a portion of the auxiliary apparatus already installed is designed for a maximum of 185 lb. and will require the use of reducing pressure valves. However, the entire steam plant will eventually be operated at the higher pressure.

To install this amount of steam-generating equipment in a new station would not be difficult, but in rebuilding and rearranging a boiler plant of this size during the actual operation of the remainder of the station, many complicated situations have arisen. The task, however, has not been impossible, and up to this time all plans have been carried to a successful completion without interrupting the service.

No comprehensive war plan can be carried out without the full coöperation of the whole people. The people will not back up any project which they do not believe sound in principle and necessary for the good of the country. There are some propositions involving merely economic policies upon which the people will take sides and follow leaders more or less blindly, although they may not fully understand the principles involved; but when it comes to the question of war which calls for the sacrifice of all they hold dear, even to their lives, they must not only understand the necessity, but they must have a deep-seated conviction of the righteousness of the cause.—*A. M. Lockett.*

It seems certain that the war will, if it has not already, open up a more extended field for the engineer. In the great emergency all belligerents have organized their industries on an unprecedented engineering basis. Some of the most conservative engineering societies abroad are taking up languages and economics in order to better fit their members to handle the broader work that they will be called upon to do.

The Diary of a Short-Circuit

By F. J. WELLHOUSE
Switchboard Engineer, Westinghouse Electric and Manufacturing Co.

A popular description of the events that take place in the life of a short-circuit, and how these events are controlled so as to interfere only with the circuit on which they occur.

FIRST instant: A stray limb and a couple of live wires get together and I, a short-circuit, am born—a devil in long pants. Second instant: I swell up like a Zeppelin all over the system. My size is perhaps a dozen times the normal current and is limited only by the reactance of the generator, the transformers and the lines to my birthplace. My growth is so rapid that no mechanical motion of devices can take place before I reach my largest size. I cause great mechanical strains in all the apparatus I rush through. I rush from the generator to my birthplace, to burn up my parents. Third instant: My enemy, armature reaction, beats me down to about half size before the quickest circuit-breaker can kill me. Fourth instant: The little time-limit relay holds the circuit-breaker in until the armature reaction beats me down to about three times normal-current size. Fifth instant: I am rushing around through all the paths, trying to get to my creators. I go into the substation on one line and come back on another to my parents that gave me life. The relays are working to select the path I shall follow. The reverse-power relay on the line where I go into the substation keeps the trip open on that circuit-breaker so that the

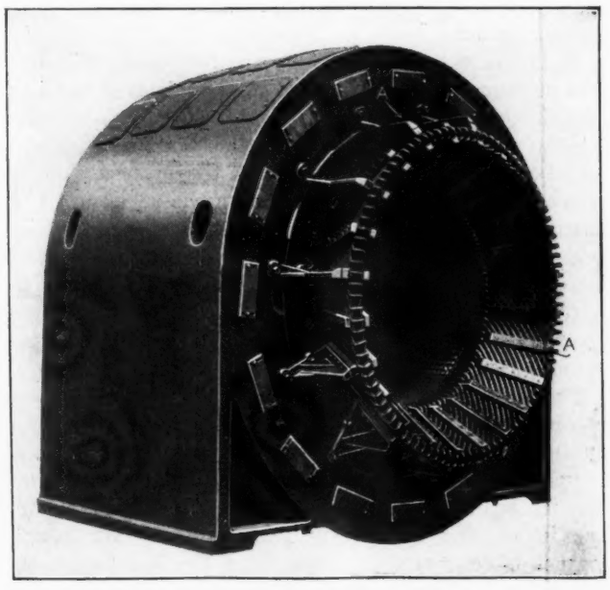


FIG. 1. SHOWS BRACING OF COIL ENDS OF AN ALTERNATING-CURRENT GENERATOR

substation will not be put out of service, but the reverse-power relay on the line where I come out to burn up my source closes the trip coil on its circuit-breaker and it opens, cutting off this path. Sixth instant: The only path left is from the generator direct to my cause. The time-limit relay on that path is closing. I am about to be killed. Seventh instant: The relay has closed and the circuit-breaker contacts are parting, my last chance—the arcing tips. Eighth instant: The arcing tips have parted; I have changed to fire; the oil has quenched me; I have turned to gas—a gas of tremendous pressure, but the oil circuit-breaker tanks can stand the strain. Ninth instant: I rise to the top of the

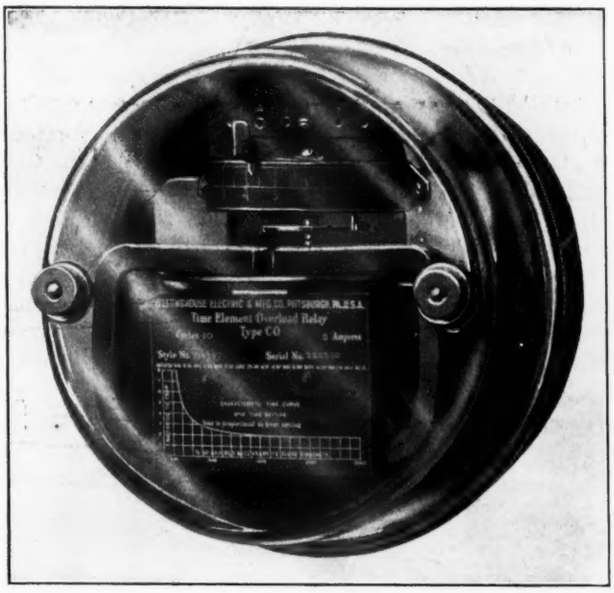


FIG. 2. TIME-LIMIT, OVERLOAD RELAY

tank, expand in the air chamber and piffle out through the small gas vents—my whole life gone—yet what a wonderful life of two seconds.

The habits of a short-circuit are perhaps the liveliest, most fascinating and mysterious of anything connected with a power system. The foregoing prelude suggests the course of action of a short-circuit and the nature of the apparatus involved in controlling it. The elements that come into play during the remarkably short period between the time that a short-circuit occurs and the time the lines are cleared will now be more fully described.

In a power system of any size, there is a generating plant of one or more units, one or more step-up transformer banks, a transmission line or two (usually two or more), a substation containing a step-down transformer bank or two, and a low-tension distribution system.

The current that flows over this system under normal conditions is limited by the impedance of the receiving apparatus, such as motors, lamps, etc., and the impedance of the lines, transformers and of the generators themselves. In practice the generators have about 8 per cent. impedance, the transformers 5 per cent., the lines 3 to 15 per cent., and the load the remainder. When we say that the generators have 8 per cent. impedance, we mean that at full load 8 per cent. of the generated voltage is lost in the generator. Also in the transformer with a 5 per cent. impedance there is a 5 per cent. voltage drop with full-load current flowing.

Under normal-load conditions the voltage drops a certain amount in each step of the power system, until at a motor or lamp where the largest drop occurs. The current that flows, as stated above, is limited by all these impedances. If a wire, a wet branch of a tree, or some such conductor of current having very low impedance should fall across the transmission line, it is readily seen that the impedance of the substation and all the apparatus, beyond the point where the fault occurred, is cut out, and only the impedance of the line, the transformer and the generator is left. This very low impedance will allow a very large current to flow, which is the "short-circuit" current.

The amount of current that can flow through this short-circuit of, say, 8 per cent. generator impedance, 5 per cent. transformer and 3 per cent. line impedance, a total of 16 per cent., would be $\frac{100}{16}$, or 6.3 times full-load current of the generating station. If the short-circuit was at the terminals of a generator or on the bus with only the 8 per cent. impedance of the generators behind it, the current would rise to $\frac{100}{8}$, or 12.5 times full load of the station. The current rises to this value at the very instant of the short-circuit. This heavy current sends out a tremendous amount of magnetic lines, which put enormous mechanical strains on all the conductors carrying the current, forcing them apart or pulling them together. Nearly all large machines are well braced with wood cleats and steel rings to prevent distortion of the windings at this time, as shown in Fig. 1 at *A*. These magnetic lines also react on the field of the generator, cutting down its magnetic lines so that the induced voltage is reduced. This reducing of the voltage in turn reduces the short-circuit current, consequently reducing the strain on the equipment.

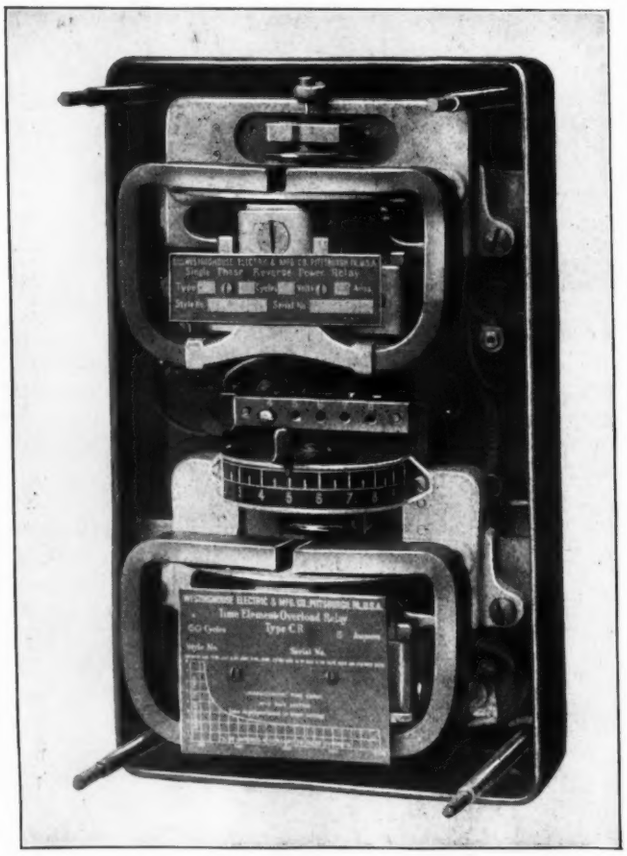


FIG. 3. SINGLE-PHASE, REVERSE-POWER RELAY

The short-circuit current therefore reaches a peak at the instant the fault occurs, but is reduced during the next few cycles (usually two or three) by the armature reaction. This time is, of course, by far too short for any mechanical operation of circuit-breakers. It is well, too, because as the current is reduced, there is less current to break when the circuit-breaker does open. The quickest circuit-breakers operating "instantaneously" open in about the time the short-circuit current has been reduced to approximately one-half of the initial rush.

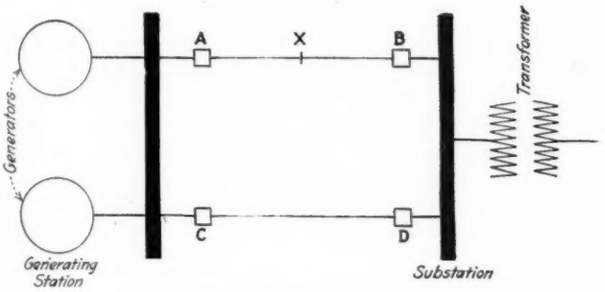


FIG. 4. LAYOUT OF CIRCUITS BETWEEN GENERATING STATION AND SUBSTATION

The armature reaction will reduce the current to approximately three to four times normal full-load rating, and the generator will continue to send out a current of this value, until it burns out its insulation or the circuit-breakers open. This current is usually called the sustained short-circuit current, and the impedance that would give this value is usually spoken of as the sustained impedance. A stable condition is reached in about one to one and one-half seconds after the short-circuit occurs.

It is evident, then, that a circuit-breaker will have less current to break if its opening is delayed until the sustained value of the short-circuit current is reached, which is one reason for using a time-limit relay, Fig. 2, on oil circuit-breakers. It holds off the current from the trip coil, by a timing mechanism on the relay, until the sustained value of the short-circuit is reached. However, it is also desirable to select the circuit-breakers which are to trip, so that only those on each end of the particular line in trouble will go out, thus clearing the short-circuit and leaving the remainder of the system in operation.

This is done by the use of one-direction or reverse-power relays and the use of different time settings at different stations. The reverse-power relay, Fig. 3, contains a wattmeter element that opens with power flowing in one direction and closes with power flowing in the reverse direction. The reverse-power relay's contact is connected in series with the overload relay, which in Fig. 3 is contained in the same case as the reverse-power relay, so that they both have to be closed before the circuit-breaker will operate. This construction makes the circuit-breaker nonautomatic with power in one direction and automatic with power in the other direction. These relays are made use of to control a short-circuit in the following way:

A short-circuit at *X* on the line *AB*, Fig. 4, will get current from the generating station directly through *A*

and also over *CD* around through the substation and back through *B*. The reverse-power relays are placed at the substation, and the wattmeter element is set so that their contacts will be open with power flowing into, and closed with power flowing out of the substation. The overload elements are set for a shorter period than at the generating station. The short-circuit current will then go from the generating station out through *C*, which will begin to close, but not actually close for two seconds; then through *D*, which is nonautomatic because power is going through in the right direction; then out through *B*, which will have its wattmeter contacts closed immediately and its overload contacts in one second. The circuit-breaker at *B* will then open, and the fifth instant in the life of this short-circuit is over with. The only path left is then out through *A*, which will close in two seconds and trip the oil switch, completely cutting off the short-circuit, yet at the same time keeping the other line and the substation operating.

Final Rupture of a Short-Circuit

The final opening of the short-circuit current, such as at *A*, is the hardest on the circuit-breaker. The opening operation at *B* simply shuts off that path, but it is not "killed," as it is at the final breaking. This final rupturing of a short-circuit on a power system of considerable size is an important problem. As plants grow larger, a circuit-breaker having a larger rupturing capacity is required. It is evident from the foregoing that with a large number of generators giving three or four times their combined full-load current into a short-circuit, a circuit-breaker has a considerable current to break. Its size depends, not upon the load current of that particular line, but upon the combined capacity of the generating plant behind it.

Oil circuit-breakers are made for different rupturing capacities in addition to their normal-current carrying capacity or their voltage capacity. This rupturing capacity is governed by the amperes the breaker has to rupture at the time of the short-circuit.

When the relay has closed, the trip coil pulls up a plunger which in turn trips a latch releasing the breaker mechanism. The contacts, which are always in a tank of oil, move downward as the breaker opens. There are two sets of contacts *A* and *B*, Fig. 5; *A* is made of sufficient size to carry the full-load current of the line, and *B* is a smaller contact that opens after the current-carrying parts have separated. This is called the arcing tip because, opening last, it breaks the arc.

The Functioning of the Arcing Tips

After the current-carrying contact *A* has traveled about an inch through the oil, the arcing tips *B* begin to part, and the heavy current passing across the small space creates an arc. This lasts until the alternating-current wave passes through zero, when the oil rushes into the space and breaks the arc. If the distance of the arcing tip from the upper contact is not great enough when the next wave occurs the arc may reëstablish itself and burn until the next zero point is reached. By that time the distance is great enough so that the oil, flowing into the gap, will completely quench the arc.

In the meantime this burning of the arc has created a gas, whose amount and pressure depend upon the size of the short-circuit current. A large short-circuit current, such as is produced by a number of large machines in parallel, generates a gas of tremendous pressure at the point of burning. It will be in the form of a bubble down in the oil, and will be forced up to the surface by the buoyancy forces.

There is always a considerable air space in the tank above the oil level where this high-pressure gas can expand, thereby reducing its pressure. On some of the larger oil circuit-breakers there is an opening in the top of the breaker, having baffle-plates that prevent the oil from squirting out, but allow the gas to pass freely. In the smaller capacities this final "gasp" of the short-circuit is out through the small openings around the operating rods.

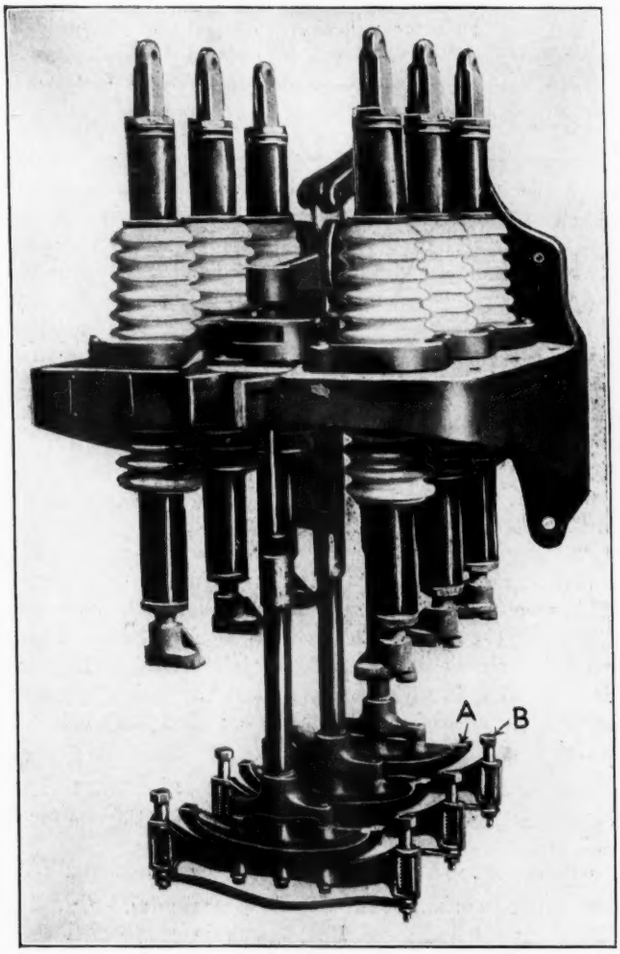


FIG. 5. OIL CIRCUIT BREAKER, SHOWING MAIN AND ARCING CONTACTS

Short-circuit currents must be taken care of in a very short space of time. They must be held long enough, however, to get a selective action between lines and to allow the current to be reduced by the reactance of the circuit. The heavy current produces a great amount of heat, and the insulation and even the conductors would soon be destroyed if the circuit was not opened within a short period afterward. Synchronous apparatus, such as rotaries or generators, will fall out of step due to the low voltage during this short-circuit period, if the defective circuit is held closed for more than about two seconds, and will therefore have a tendency to disturb the operation of the system in general.

Tom Hunter, Hoisting Engineer

BY WARREN O. ROGERS

Two types of valve-reversing gear were seen at the Tamarack mine. On one the shifting of an intermediate gear throws the wristplate from the go-ahead position to reverse; the other one performs the same function by means of a double-quill gear on which a sleeve slides from one end to the other. Hunter also tells why a long-range cutoff on an engine is desirable.

AS THERE were at the Tamarack mine several machines that we had not seen, a return visit was made the next day. The first one was a small twin Corliss second-motion man hoist. The drum was of odd design, being in the shape of a frustum of a cone, Fig. 1, instead of a double cone, as were most of those we had seen. At No. 3 shaft we found an Edward P. Allis twin-Corliss hoist operating a double skip from a double-cone drum.

"You will find that the reversing gear on this hoist is different from anything we have yet seen," said Hunter. I had noticed that and made ready to photograph that part of the machine (Figs 2 and 3).

"This valve gear," continued Hunter, "is operated by a shaft driven from the crank and drumshaft by gears. This secondary crankshaft runs parallel with the drumshaft and carries a crank disk on each end, from which a carrier arm extends to the wristplate of each cylinder. Motion is given to this shaft through a train of several gears and two sections of shafting, between which is an intermediate gear."

HUNTER EXPLAINS CUTTING OF THE SHAFT

"I don't see what's the use of cutting the shaft in two pieces and connecting them with gears."

"You will, before I get through. This is the way the thing works," said Hunter, sketching Fig. 10. "There is a bevel gear *A* on the main crankshaft that meshes with a gear *B* on the first section of the shaft that runs parallel with the engine frame. In fact, there is a bevel gear on both ends of both shaft sections, the outer one *F* meshing with the gear *G*, on the auxiliary crankshaft, as I have already stated. Now, between the two central bevel gears *C* and *E* is an intermediate gear *D*, which is mounted on a movable stud and which is moved to an upper or lower position (Figs. 2 and 3) by a plunger from a steam-actuated piston that is controlled by a lever from the operating stand. As the gears *B* and *C* cannot turn when the gear *D* is moved up or down, the gear *E* must move, and in so doing changes the position of the crank that actuates the wristplate. This movement throws the catchblock on the valve gear into engagement at either one end of the cylinder or the other.

"When the intermediate gear *D*" Fig. 10, "is in its top position," Fig. 2, "the gear spindle is at an angle of about 45 deg. and the engine will run under. When the gear *D* is moved to its lower position," Fig. 3, "the engine will run over. Of course the shaft *H*," Fig. 10, "actuates the valve gear on the opposite side."

The beam brake on this hoist is shown in Fig. 4, but Hunter did not bother with it, as he had already made the action of that type of brake clear.

After we had thoroughly examined this hoisting plant, Hunter suggested that we go to No. 2 Tamarack, where there was another Allis engine having a still different kind of reversing gear. The camera was put to work, and Figs. 5 and 6 were obtained, which show the quill sleeve of the gear in its two extreme positions. The quill shaft is in two sections with the quill on the inner ends. The sliding sleeve, as it is moved from one end of its travel to the other, causes the quill connecting with the valve gear to make a partial revolution, which moves the valve gear for either a forward or reverse rotation through the gear shown, and a layshaft below it.

The engine other than the reversing gear had nothing of special interest, and we soon left to take in No. 2 compressor plant.

ANOTHER LEAVITT-MORRIS ENGINE

"Well," said Hunter, "here we have another Leavitt-Morris rocker-compound condensing engine." See Figs. 7 and 9. "There is no use talking, they certainly put out a great machine in those days. I can't get away from the finish they put on all the parts. In most particulars the design of this engine follows that of the others we have seen of like make, in that it employs rockers to transmit the piston motion to the crankshaft proper. The cylinders are 27½ x 48 x 72 in.

"This engine drives by means of a spur gear on the crankshaft, a two-stage duplex compressor. A duplicate unit in another room can be driven from the outer end of the shaft, but is not connected at the present time. Owing to the compressor being set lower than the engine, the crankshaft runs above the compressor frame." See Fig. 8.

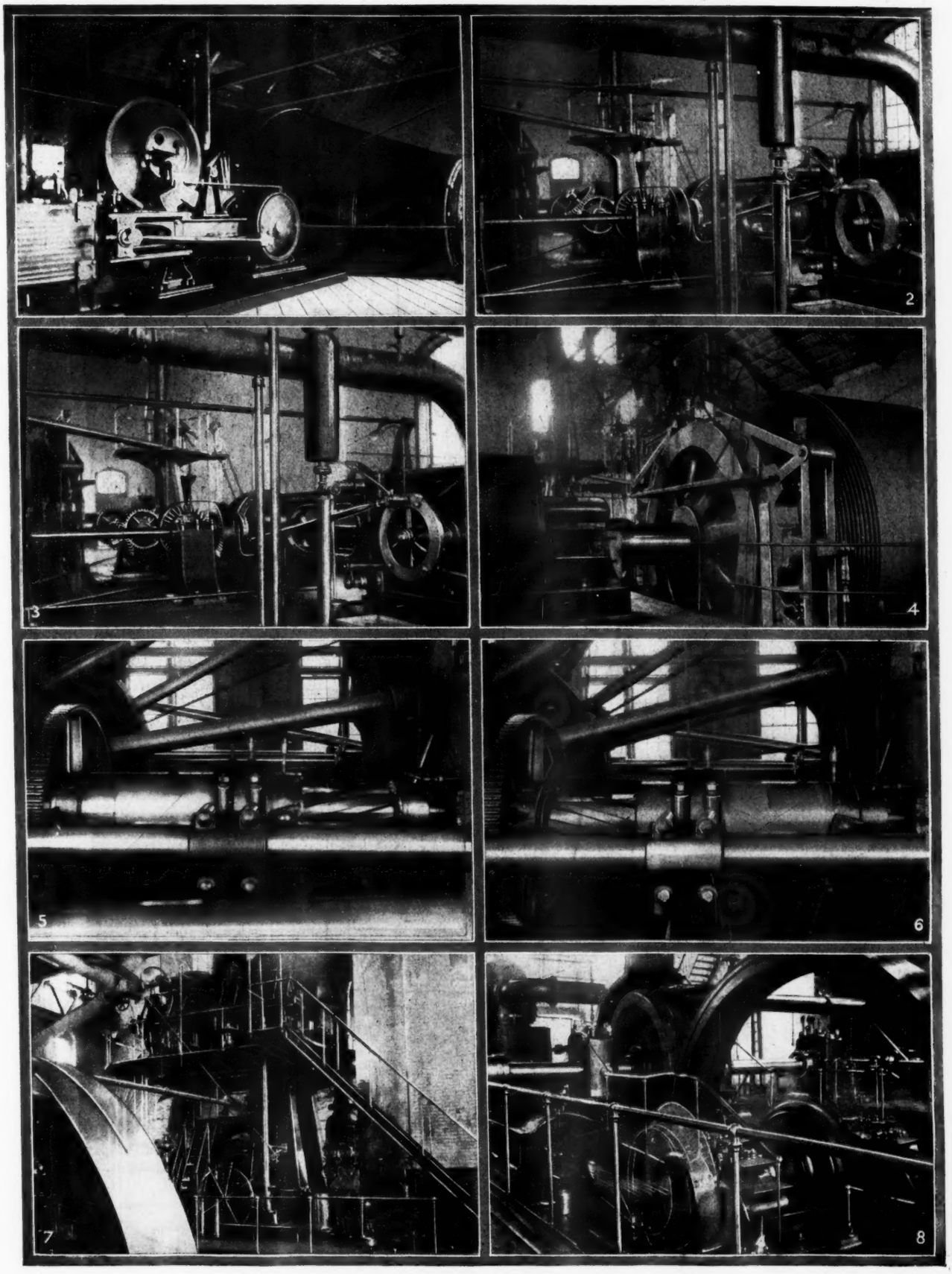
LARGE TWO-STAGE COMPRESSOR

We next went to No. 5 compressor plant (Fig. 11). This plant supplies the air for Nos. 3 and 5 Tamarack mines. The largest compressor was a triple-expansion two-stage Nordberg. It was of the three-crank type, the three cylinders working on separate cranks set 120 deg. apart.

"The work of that machine," said Hunter, "is carried by the three steam cylinders and that properly requires an equal division of the load on each of the cylinders in order to reduce the work to be borne by the crankshaft and the flywheel as low as possible. The steam cylinders are next to the frames, and behind each steam cylinder is a high- and a low-pressure air cylinder. You see, with that arrangement there is on each crank a complete two-stage compressor."

"I should think that with such large units, in case of an accident to one of the air cylinders, the whole machine would be put out of service and cause all kinds of trouble."

"That is the beauty of that machine. Don't you see that with a complete compressor on each crank, if one cylinder gives out that unit can be disconnected and



FIGS. 1 TO 8. VIEWS TAKEN AT THE TAMARACK MINES

Fig. 1—An odd-shaped drum. Figs. 2 and 3—Allis reversing gear. Fig. 4—Beam brake. Figs. 5 and 6—Another type of reversing gear. Fig. 7—Rocker-compound engine. Fig. 8—Method of driving compressor.

the other two operated as usual? Of course the total output of the machine, which is 8800 cu.ft. of air per minute, would be reduced one-third, but the mine would not be wholly cut off. There is a detachable coupling on the piston rod between the steam and air cylinders, which is convenient in case of accident, and valves are also provided in the connection to the intercooler and in the discharge connection, so that any one of the three compressor units can be uncoupled and the others kept running until repairs can be made."

"Well, matters seem to have been arranged for a possible breakdown, and it looks as if the thing could be kept running unless the whole machine goes to pieces."

At the other end of the compressor room we found a tandem-compound engine driving a 150-kw. generator (see foreground, Fig. 11).

"That engine," said Hunter, as I got the camera ready for taking a view of the room, "is equipped with a long-range valve gear."

"You may know what you are talking about, but I don't. What do you mean by a long-range valve gear?"

"Well, the original Corliss engines were designed with a range of cutoffs limited to about one-half the piston stroke, because when the eccentric has reached its extreme throw in either direction, all the valve-gear motions are reversed, and of course the steam valves must be released before the eccentric motion is reversed, otherwise the engine would be using steam full stroke.

"One way of getting a greater range of cutoff is to use a separate steam and exhaust eccentric, so that the steam and exhaust valves can be adjusted independently and the steam can be cut off at any point to nearly the end of the stroke. You will notice that in the oscillating cam," Fig. 11, "there is a slot on two planes, and when the roller passes from one slot to the other, the hook block releases or disengages the valve. If the

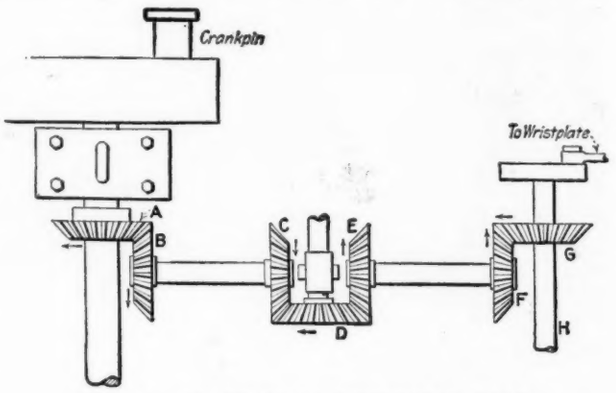


FIG. 10. DIAGRAM OF REVERSING GEAR

speed of the engine is below normal, the governor will be resting on a collar and the roller will remain in the lower slot; the valve will be hooked up and the steam will be admitted full stroke to the engine. On the other hand, with the engine at normal speed and no load, the governor will be at its highest position, the roller remaining in the upper slot of the cam, and the valve will remain disengaged and of course no steam will be admitted to the cylinders. So you see that with this particular valve gear cutoff takes place coincident with all the intermediate positions taken by the governor, which changes the center of oscillation of the cam between the two extreme limits.

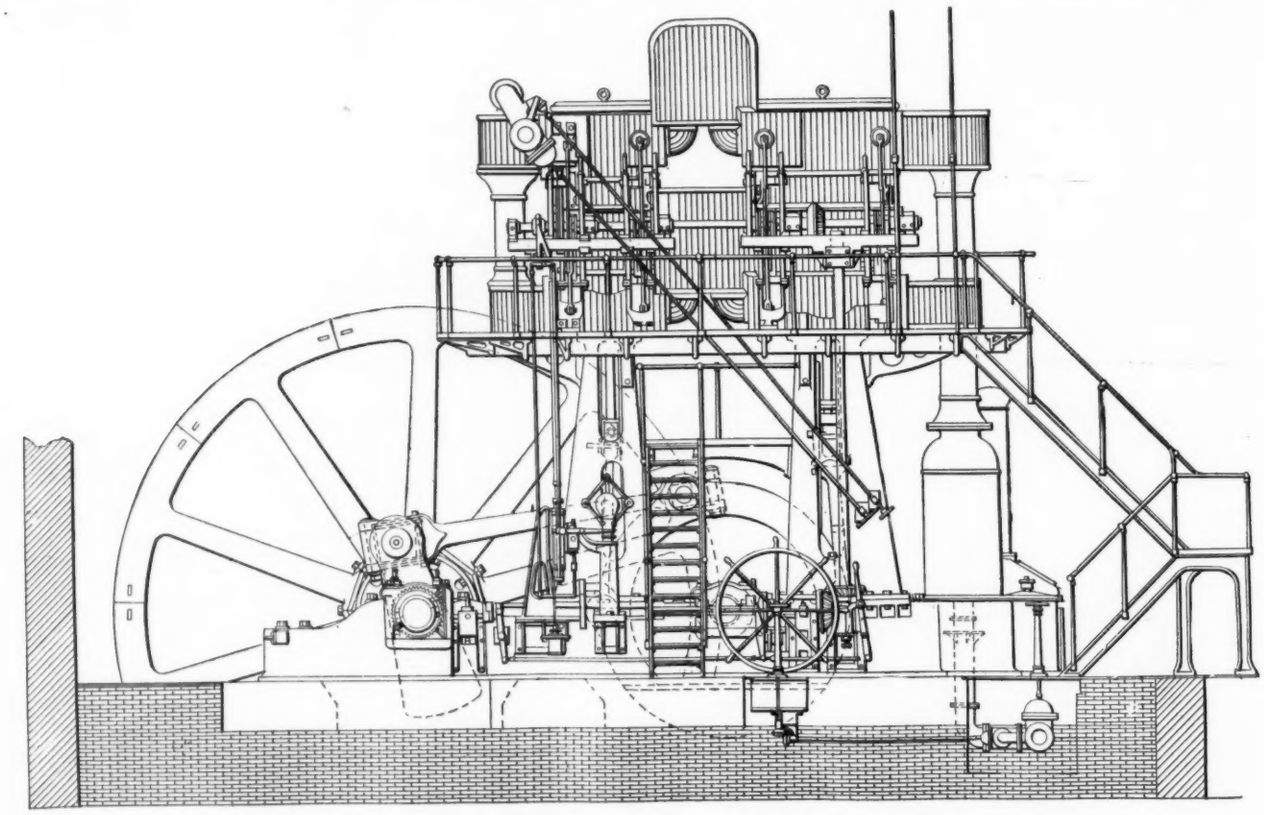


FIG. 9. SIDE ELEVATION OF FRONTENAC ENGINE, SHOWING GENERAL DESIGN

"This long-range cutoff enables the engine to carry high overloads such as occur with the sudden peaks, without affecting the regulation of the engine, and furthermore the engine can carry an overload with a steam pressure below normal."

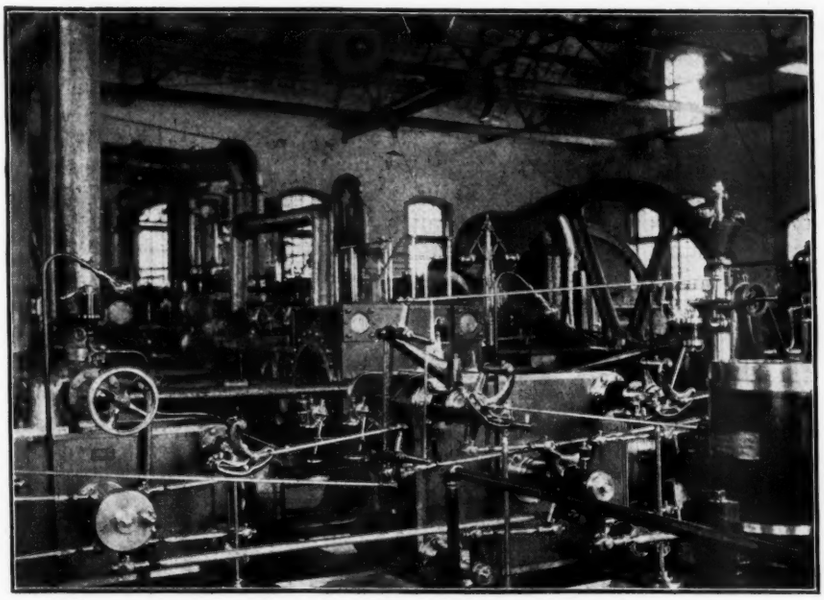


FIG. 11. COMPRESSOR FOR NOS. 3 AND 5 TAMARACK MINES

"It should be a good thing for a compound engine," I remarked, as I began packing up the camera.

"It is," replied Hunter, "as the practice these days is to use high cylinder ratios, the high-pressure cylinders sometimes being but one-fifth the size of the low-pressure cylinders. Under such a condition at normal load, the point of cutoff in the high-pressure cylinder is mighty near the limits of the range of the ordinary valve gear, but a long-range cutoff will allow the engine to carry a heavy overload. You know it is desirable to equalize the work in both the high- and the low-pressure cylinders, and the point of cutoff in the high-pressure cylinder is about the limit of the ordinary gear. That is the reason that many engine builders make the high-pressure cylinder of compound condensing engines larger than they should be for the best economy." By the time we finished with the compressor, it was beginning to get dark, and we started for the hotel. "Where'll we go tomorrow?" I asked, as we reached the outskirts of the town. "I propose that we take in the stamp mill at Lake Linden, where the rock from the Calumet & Hecla mines is treated, ready for the smelter. It is an interesting proposition and there are some large pumps of various types and a collection of engines in the power plant that are worth looking over."

Hot-Water Heating Under Forced Circulation—I

By CHARLES D. ALLAN
Consulting Engineer for the Mechanical Equipment of Buildings, Chicago.

The first of a series of six articles dealing with the subject of hot-water heating under forced circulation. The present article explains the elemental mechanical principles of hot-water heating.

IT IS hardly more than fifteen years ago that hot-water heating under forced circulation was first put on the market in this country, backed by numerous claims of superiority over steam heating, chief of which were the following:

The cost of carrying heat over a distance as measured by the power taken to operate the circulating pump is low.

Return lines do not have to be laid to grade or at a level below the lowest radiation.

The temperature of the circulating medium can be changed at the central plant to suit the varying demand for heat, due to changes in outside weather conditions.

The absence of mechanical devices such as thermostatic return valves, traps, etc., for condensation.

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The elimination of back pressure when exhaust steam is used, due to its heat being transferred to the circulating water through the medium of a tubular heater with open vent.

Absolute noiselessness.

Notwithstanding the double handicap of excessive first cost and imperfect designing, which is inevitable in the development stage of any process, its inherent correctness of principles has enabled these claims to be substantially made good, so that it is today well established as a thoroughly efficient method of heat distribution.

It is not suitable for very high buildings by reason of static pressure, and the conditions under which its advantages are most apparent are in the group heating of buildings of moderate height such as prevail in industrial plants and public institutions, many of the largest of which are now warmed by this method.

To those unfamiliar with these large installations, sometimes having several hundred thousand square feet of heating surface and circuits over a mile in length, their continuous operation without a single cold radiator seems so complicated and bewildering as to defy analysis, but like any other engineering subject, it is

easily understood when the fundamental principles are mastered.

In recognition of the singular lack of published information on this subject, it is purposed to explain the elemental mechanical principles so that engineers desiring a thorough knowledge of the subject may have as a basis of further investigation data which have stood the actual test of practical designing. The elements of the system are shown in Fig. 1. A pump circulates water in a circuit in which, after leaving the pump outlet, it passes through a boiler or tubular heater, from thence through the radiation and back to the pump inlet.

As the circuit is closed, the pump works only against the head necessary to overcome friction and not against

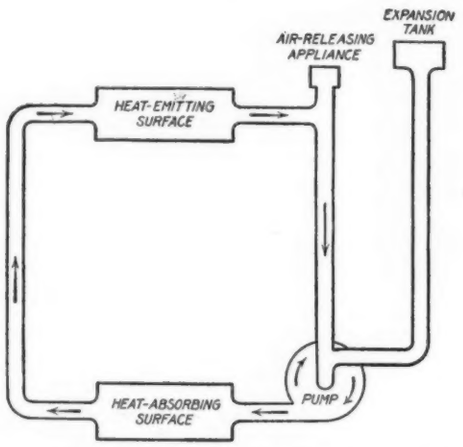


FIG. 1. DIAGRAM OF HOT-WATER HEATING SYSTEM

any head due to the height of the water column, which is the same on both inlet and outlet side, the rising and descending columns being balanced. As air will collect at high points and remain there unless removed, an air-releasing apparatus is shown where the return line turns down. An expansion tank, placed above the highest point of the circuit, is connected to the inlet side of the pump, where the pressure is least when the pump is in operation.

Under the heading of mechanical details only those which are distinctive of this method of heating will be given, it being assumed that those interested in the subject are familiar with the method of figuring hot-water radiation and the prevailing mechanical construction of heating systems and piping work in general.

In steam work the heating medium, after entering the radiation units, is condensed to water, thereby entirely changing its physical condition; and though the steam-carrying pipes are designed to carry steam only to the radiators, they will perform their function in a fairly satisfactory manner even though the sizes used are far from being theoretically correct. In water heating, on the other hand, the heating medium must pass through the individual radiators or coils and back to the source of heat in a practically unchanged physical condition. The natural laws of mechanics will so direct this flow that the friction-head loss is the same through all circuits from the pump outlet and back to its inlet, and the sizing of pipes must be such that the drop in temperature due to heat emission from the radiation in the various circuits will also correspond. Since this is a problem in hydraulics, it will be necessary to consider the elementary principles of this branch of engineering which apply to the subject in hand.

In hydraulic engineering, pressure is always designated in terms of the head in feet, or in other words, the distance in feet below the surface of still water at which the pressure in question will prevail. This head is a multiple of pounds per square inch on the basis that each 2.31 lin.ft. height of water column will give a pressure of 1 lb. per sq.in. at its base.

When water flows through a pipe, it requires a difference of head at the inlet and outlet ends to overcome the friction of the water against the walls of the pipe and an additional head to impart velocity, this being graphically shown in Fig. 2.

Suppose that the water level in the tank F is automatically kept at the line AB. If there were no friction at the outlet D, the water would then flow out of this orifice at a velocity in feet per second equal to $\sqrt{2gH}$, the well-known formula for the velocity of a body falling freely in space, in which g is the acceleration in feet per second due to gravity (32.16) and H is the height in feet corresponding to H in the diagram.

The velocity of the water through the orifice E will be much less than this, as all of H will not be available to impart velocity, the larger part of it being used to overcome the frictional resistance in the pipe C, so that the velocity of flow from the outlet E will be $\sqrt{2g(H - H_F)} = \sqrt{2gH_V}$, in which H, H_V and H_F correspond with the diagram and are known as the total or "dynamic head," the "velocity head" and the "friction head," respectively, the relation being $H = H_F + H_V$.

The velocity head H_V cannot be measured by lateral pressure against the walls of a pipe or conduit in which

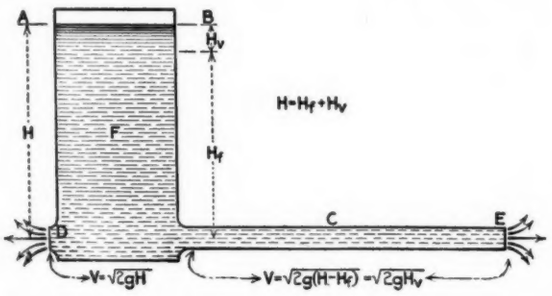


FIG. 2. DYNAMIC, FRICTION AND VELOCITY HEADS

water is flowing, as for instance by connecting an ordinary gage, as it exists in the form of kinetic energy, or the energy of motion, and can be measured only by direct impact, as for example when a pitot tube is inserted.

In water-piping systems the velocity head H_V is exceedingly small as compared to the friction head H_F, a velocity of 10 ft. per sec., about the maximum used in forced hot-water heating, corresponding to a head of only 1.55 ft., while H_F might be as high as 125 ft. if the system were extensive enough.

Hence H_V is negligible as pertaining to the subject matter, the friction head H_F, or the height of a water column necessary to overcome the frictional resistance in the piping system, and its relation to diameter and the velocity and volume of flow being the essential information that is necessary in work of this character.

Operation of Mechanical Stokers

By H. F. LAWRENCE
Test Engineer of the American Engineering Co.

This article, which describes the practical operation of several types of Taylor stokers, was received subsequent to the publication of a series of articles dealing with the operation of mechanical stokers generally.[1]

IN THE Taylor stoker the green coal is fed from the retort beneath the burning fuel, the air for combustion being introduced at the mouth of the retort, also beneath the burning fuel. To prevent premature distillation of the volatile gases, it is necessary that the coal be closely packed in the retorts. This is accomplished by the friction in a retort of proper design, together with the weight of the fuel bed. As the fuel leaves the retort, the pressure is gradually relieved by the flare of the tuyeres and the fuel spreads over them. The distillation begins when the pressure is relieved at the mouth of the retorts, and the volatile gases as they rise are thoroughly mixed with the air and together with the air pass through the incandescent bed of coke. This insures the intimate mixture and high temperature necessary for the proper combustion of the hydrocarbon gases. As the coke is burned, the ash remains on top and the replenishing of the fuel bed forces the ash to be continuously deposited at the rear on the dump plates.

For supplying the required amount of air and at the same time accomplishing the necessary thorough mixture, high velocities and consequently high pressures at the tuyeres are imperative.

This in general is the theoretical operation of the stoker, and practically to secure the best results theoretical operation must be closely approached.

Type "A" stoker is shown in Fig. 1. When properly adjusted and operated, the fire will pass through a

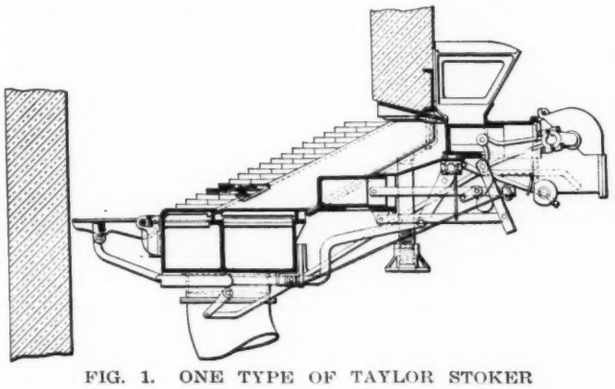


FIG. 1. ONE TYPE OF TAYLOR STOKER

regular and natural cycle. The mixture of ash and devolatilized fuel will be deposited on the dump plate to a depth of approximately 12 or 15 in. While the stoker continues to feed fuel, more material is deposited on the dump plate only as the fuel already on it burns away and makes room for it. The end of the natural cycle (three or four hours) is indicated by the material on the dump plate having a flat and dead or blackened appearance. This shows that it is time to dump. After dumping, the long stroke of the lower rams should be used for a short period, not exceeding ten minutes, after which the cycle will repeat itself; provided, of course, the relation of air to coal is maintained correct.

It is essential to maintain a uniform emergence of the fuel from the mouth of the retort. This is accomplished by adjusting the stroke of the lower ram to the proper amount, which can be readily done without in any way interrupting the operation of the stoker.

Fig. 2 shows the type "AA" stoker, which was first built in 1910. The difference in the two types is in the addition of an overfeed grate between the power-operated dump plate and the retort. Forced draft is supplied to the overfeed grate and is regulated by a

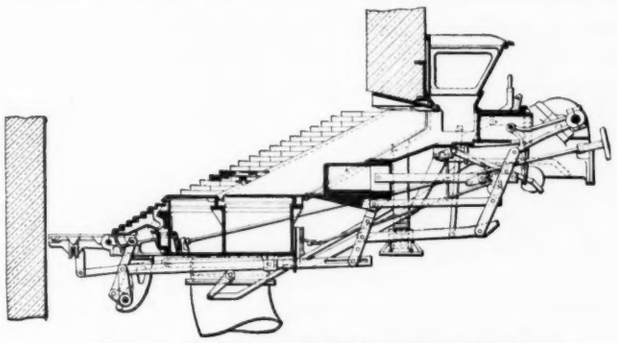


FIG. 2. STOKER WITH OVERFEED GRATE

hand-controlled air damper. Later developments have indicated, however, that overfeed grates can be used to only a limited extent with good economy. The fuel bed immediately over the retorts must be maintained uniform and compact.

As the devolatilized fuel and ash is discharged from the retort over the overfeed grate, it loosens and breaks up so that very slight air pressure is required on the overfeed grates. It is area of the air openings and not pressure which is required in this section of the fuel bed. The high velocities and direction of air flow are required in the retort where the coking and volatilization of the fuel takes place. For these reasons the air opening area of the overfeed grates is considerably greater per square foot of grate surface than the tuyere opening area. With normal coal-burning rates, which include up to 500 lb. of coal per retort per hour, no air pressure is required on the overfeed grates. Sufficient air is supplied by leakage through the dampers.

Just prior to the dumping period, for an interval of about 15 minutes, air may be used on the overfeed grates for the purpose of rapidly burning out the coke from the ash. At higher rates of combustion, except immediately after the dumping period, it may be desirable to open the overfeed-grate air dampers slightly, but it is never necessary or good operation to open these dampers fully, except for a short period before dumping. When the opening of the air dampers to

[1] See *Power*, page 648, May 15,; 692, May 22; 737, May 29; 764, June 5; and 794, June 12, 1917.

the overfeed grates appears ineffective, it is an indication that something is wrong in the operation and not that more air is required at this point. If the air pressure used has been correct for the amount of coal fed, the trouble is due to one of two causes—either the dumping period has been extended through too long an interval of time, or the distribution of the fuel from the mouth of the retort has been uneven; both of which causes would allow an accumulation of clinker at the top of the overfeed grates, which would also extend back into the retort, thereby making the rear of the fire excessively heavy and causing unburned fuel to be deposited over the dump plates and overfeed grates. The remedy for this condition is to sacrifice the unburned fuel immediately on the dump plate, clean this clinker out quickly and start with a clean furnace, being careful to make the necessary changes in operating methods so that the trouble will not occur again. To secure the best results, the maximum burning of fuel must take place at the mouth of the retort and not on the overfeed grates.

In order to secure higher fuel-burning rates and even better economy, the type "B" stoker, shown in Fig. 3, has been developed. The difference between the type "B" and type "AA" is in the size of the retort, the retort of the former being considerably larger and having two distributing rams in addition to the one main fuel-feeding ram. The dump plate is operated by power. The stoker is used where it is required to burn very large quantities of fuel. The operation and principles governing the operation are identically the same as for the smaller stoker.

Instruments for indicating the operating conditions are valuable and essential for obtaining the best results

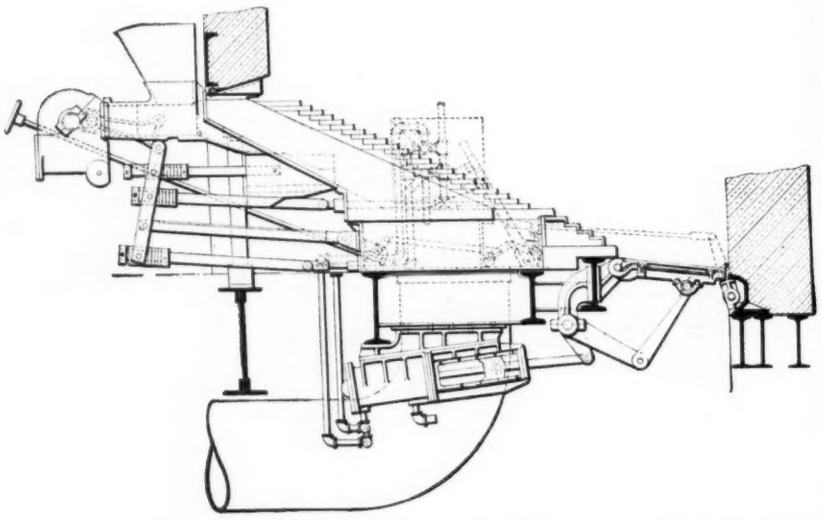


FIG. 3. STOKER HAVING TWO DISTRIBUTING RAMS IN ADDITION TO THE MAIN FEEDING RAM

and should be as simple as possible. No instrument or combination of instruments should be expected, however, to replace observation of the fire. The only correct and satisfactory method is to combine the use of the instruments with intelligent observation of the fire.

With the type "A" stoker 200 per cent. of boiler rating is readily obtained for periods of approximately four hours. With type "AA" 200 per cent. of rating is obtained continuously and 250 to 300 per cent. of rating is obtained for peak-load conditions of short periods. At normal rates the ash is burned out to a greater extent with the type "AA" than with the type "A." With the type "B" the coal-burning rates have been materially increased over the type "AA" and 300 per cent. of rating will be obtained continuously. Because of its high fuel-burning rate it also meets a condition where high capacities are desired with low-

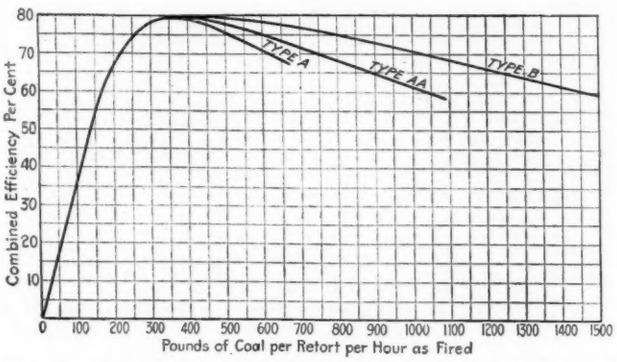


FIG. 4. SHOWING COAL-BURNING CHARACTERISTICS OF THREE STOKERS

grade fuels. Moreover, it applies to good advantage where the furnace width is narrow in proportion to the heating surface of the boiler and also when extremely high capacities are desired for long periods of time.

Curve Fig. 4 shows the coal-burning characteristics of stokers of types "A," "AA" and "B".

Fig. 5 shows the patented rotary ash-discharge system as applied to the Taylor stoker. The speed of the crusher roll and the opening for the discharge of ash from the crusher can be varied through a sufficient range so that any kind of coal can be used. The rotary crusher is applied only when plant conditions are such as to warrant its use. When properly and intelligently adjusted, the stoker equipped with this form of ash discharge will continuously give very high efficiencies. In other words, when a correct operating condition is obtained, this condition can be maintained for many consecutive hours. The combustible in the ash is somewhat lower than with the dump-plate type of stoker. Owing to the fact that a set of conditions once established is carried on hour after hour, it is obvious that more intelligent operation is required with the rotary crusher than with the dump-plate type stoker. With the latter every few hours at the time of dumping a very exact observation of the fuel-bed condition and structure is obtained, while with the rotary the view obtained at any time is merely of the surface of the fuel bed. This requires care and judgment on the part of the fireman, in order that a wrong condition may not exist through an extended period of time.

In general the rules for operating the stokers are as follows:

The fuel-bed thickness that is best will vary somewhat with different coals; that is, coals having different

burning characteristics. A good coking coal will in general require the heaviest fuel bed; free-burning non-coking coals require the lightest fuel bed. Determine by trial and error the correct stroke of the lower ram for maintaining a uniform and even fuel bed of the proper thickness and determine the length of the dumping period, taking care not to extend this too long. More trouble can be caused by running too long between dumps than by anything else. A slight draft over the fire is sufficient and it should not exceed 0.1 in. water gage. Normally, use no air on the extension grates except for short periods to burn out the combustible in the ash. Use the long stroke of the lower ram for short periods after dumping, not more than ten minutes at normal rates and at maximum rate probably not at all.

At least once every 24 hours clean any accumulation of clinker from the side walls of the furnace; oftener if found necessary.

To build a fire, operate the stoker until a few of the top tuyeres are well covered with coal, the lower tuyeres being bare. Then stop the coal feed and build a fire along the front wall. Either wood kindling or burning coal taken from other fires can be used. Use no forced draft. Allow the coal along the front wall to become thoroughly ignited, then feed coal slowly and gradually apply the forced draft as required. Be careful not to get green coal on the extension grates or dump plates.

It is considered good practice, because of expansion of settings, etc., to use about 1½ to 2 hours in putting a boiler on the line from cold.

To bank a fire, first shut off the air blast completely, then the dump plates are to be dumped and at least one hopperful of coal fed into the furnace. When a banked fire is to be carried for a long period, replenish the fuel bed from time to time as required.

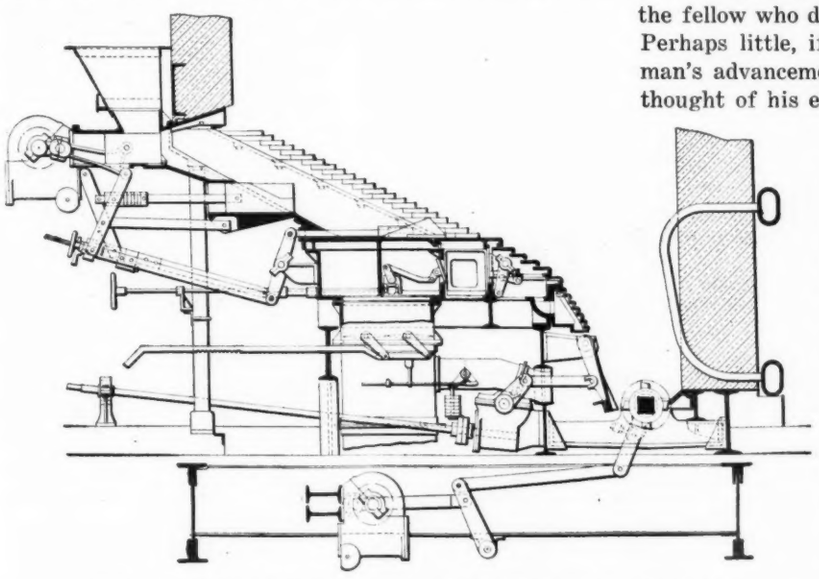


FIG. 5. STOKER EQUIPPED WITH ROTARY ASH DISCHARGE

When burning high-volatile coal, see that the hopper is empty before stopping the coal feed; in fact, it is always a good plan to empty the hopper before stopping the coal feed. If this is not done, the stoker will backfire with high-volatile coal.

Close the boiler damper as tight as possible. There is always a leakage around the boiler dampers, which is sufficient to remove any gases during the banked period. Excessive draft over the fire during the banked period will increase the quantity of fuel required to maintain the banked fire.

Just previous to starting the stoker, after carrying a banked fire, a bar should be run down the side walls to insure that no clinker has formed in these walls and obstructed the ram. Then open the boiler damper.

When starting the stoker, after carrying a banked fire, it should be allowed to operate on the long stroke for a few revolutions before putting any coal in the hoppers that have been left empty, after which the hopper can be filled and the stoker allowed to operate in the usual way.

Shearing pins are used as safety devices. The shearing-pin bushings should be inspected regularly to see that the cutting edges are in good condition. Repeated shearing of the pins indicates trouble, and the trouble should be eliminated at once. Keep the grease cups filled and all moving parts lubricated.

Stokers should receive the same care and attention as any other high-class machine. Periodical inspection should be made of the running gear and power boxes and all loose bolts and nuts tightened. Windboxes and extension-grate frames should be cleaned out periodically, chains and sprockets cleaned with kerosene, and the power boxes cleaned and replenished with fresh oil. Carelessness in maintaining the equipment induces the firemen to carelessness in operation.

Getting the Chief's Ideas

It is rather annoying for those in charge to deal with the fellow who does not seem to get the hang of things. Perhaps little, if anything, counts up more to favor a man's advancement than ability to catch the ideas and thought of his employer or immediate superior. When certain instructions are being given to you about the work in hand, etc., you must form the trait of getting the idea, or meaning, and not have to be constantly consulting your chief about what to do. Some fellows listen to instructions, and after the chief has finished them will say that they understand them; yet when they try to carry out these instructions, they mix things up or perhaps act to the contrary. This very plainly shows that they failed to get the chief's meaning or ideas. A fellow must use his thinker to make good at steam engineering. Failure on your part to do your share of thinking burdens your fellow men and your chief with the task of thinking for you, and places you in the ranks of sluggish failures.

You have been alloted the same amount of gray matter that your fellow men have. There is but one way to develop the thinker, and that is to train yourself to be attentive to instructions and reason out why they were given.—*Marine Engineering.*

The Electrical Study Course—Brown & Sharpe Wire Gage

In importance the wire table for light and power conductors may be considered to rank with Ohm's law. Different characteristics of this table are considered in this lesson. It is shown that by memorizing the values pertaining to a No. 10 wire an approximate wire table may be worked out.

THE gage chiefly used in this country for measuring copper conductors is known as the Brown & Sharpe (B. & S.) or American wire gage (A. w. g.) as it is sometimes called. This gage expresses the size of large conductors in their circular-mil cross-sectional area, and the small-sized wires by numbers. Standard wire sizes by number run from No. 40 to No. 0000; any conductor larger than No. 0000 is expressed in circular-mil cross-section as shown in the accompanying table. A circular-mil is the equivalent of the area of a circle one-thousandth of an inch (0.001 in.) in diameter. On account of the small cross-section of a number of the wire sizes, this small unit becomes very convenient. For example, a No. 40 wire, the smallest standard size, is only 3.145 cir.mils in cross-sectional area. Expressed in square inches the area is 0.0000077634, which at once makes apparent the advantage of using the circular mil as a unit of measurement.

By using the circular mil as the unit of measurement for the cross-sectional area of round wires, the area in circular mils is equal to the diameter in mils squared, or the diameter in mils is equal to the square root of the cross-sectional area in circular mils. This is evident from the following: The formula for the area of a circle in square measure is Area $=$ Diameter$^2 \times$ 0.7854. If the diameter is expressed in mils, the area will be in square mils. One circular mil is equal to 0.7854 part of a square mil. Hence to reduce square mils to circular mils, divide the former by 0.7854, from which

$$\text{Area in circular mils} = \frac{\text{area in square mils}}{0.7854}$$

$$= \frac{\text{diameter}^2 \times 0.7854}{0.7854} = \text{diameter}^2$$

The accompanying table gives various data on conductors used for light and power installations. This table covers only wire sizes down to No. 18, as smaller sizes than this are never used for light and power circuits. In fact no smaller than No. 14 is used for the circuits running to the various equipment, Nos. 16 and 18 being used only for the wiring of lighting fixtures, etc. The largest-sized conductor given is 2,000,000 cir.mils in cross-sectional area. Although this is not the largest conductor made, it may be considered to be the largest standard size, all sizes larger than this being special.

Down in the column headed "Diameter in Mils" is 500.0, and opposite this value in the left-hand column headed "Area in Circular Mils" the value 250,000 is given. This latter value is obtained by squaring 500, or 500 $\times$ 500 $=$ 250,000. This is true of all the values in the column, "Area in Circular Mils"—they are equal to the values opposite, squared, in the column headed "Diameter in Mils." As another example, 866 $\times$ 866 $=$ 749,956, or approximately 750,000; 750,000 and 866 are found in opposite columns, "Area in Circular Mils" and "Diameter in Mils" respectively.

Considering the wire-number sizes, it will be seen that the cross-sectional area is doubled or halved for every three numbers, depending on whether the sizes are increasing or decreasing. For example, a No. 5 wire is 33,100 cir.mils cross-sectional area; taking three sizes higher, a No. 2, it will be found to have a cross-sectional area of 66,370 cir.mils; 33,100 $\times$ 2 $=$ 66,200; therefore a No. 2 wire is approximately twice as large in cross-section as a No. 5. This will be found to be the case all through the table. A No. 10 wire is approximately 10,000 cir.mils in cross-sectional area; counting down six sizes to No. 16, it is found that the area of this conductor is 2583 cir.mils, or approximately one-quarter the size of a No. 10. By remembering that the cross-sectional area of a No. 10 wire is approximately 10,000 cir. mils and that the wire sizes double every three sizes, an approximate wire table may be worked out.

The reader should not confuse the cross-sectional area of a round conductor with the diameter. Although the cross-sectional areas of round conductors double

COPPER-WIRE TABLE OF SIZES, CARRYING CAPACITIES, WEIGHT, RESISTANCE, ETC.

B. & S. Gage No.	Area in Circular Mils = Dia. in Mils.^{2}	Diameter in Mils = $\sqrt{\text{C.M.}}$	Allowable Carrying Capacities of Wires: Rubber Covered	Allowable Carrying Capacities of Wires: Other Insulations	Ohms per 1,000 Ft. at 68 Deg. F.	Weight per 1,000 Ft. Bare	Copper Stranded Cable: Wires: No.	Copper Stranded Cable: Wires: Dia. in Mils	Copper Stranded Cable: Outside Dia. Bare
....	2,000,000	1,414	1,050	1,670	0.0052	6,100	127	125.5	1.632
....	1,900,000	1,378	1,010	1,610	0.0055	5,796	127	122.3	1.590
....	1,800,000	1,342	970	1,550	0.0058	5,490	127	119.1	1.548
....	1,700,000	1,304	930	1,490	0.0062	5,186	91	136.7	1.504
....	1,600,000	1,265	890	1,430	0.0065	4,880	91	132.6	1.459
....	1,500,000	1,225	850	1,360	0.0070	4,576	91	128.4	1.412
....	1,400,000	1,183	810	1,290	0.0075	4,270	91	124.0	1.364
....	1,300,000	1,140	770	1,220	0.0084	3,963	91	119.5	1.315
....	1,200,000	1,095	730	1,150	0.0088	3,660	61	140.3	1.263
....	1,100,000	1,048	690	1,080	0.0095	3,356	61	134.3	1.209
....	1,000,000	1,000	650	1,000	0.0105	3,050	61	128.0	1.152
....	950,000	974.7	625	960	0.0111	2,898	61	124.7	1.122
....	900,000	948.7	600	920	0.0117	2,745	61	121.4	1.093
....	850,000	922.0	575	880	0.0124	2,593	61	118.0	1.062
....	800,000	894.4	550	840	0.0131	2,440	61	114.5	1.031
....	750,000	866.0	525	800	0.0140	2,288	61	110.8	0.997
....	700,000	836.7	500	760	0.0150	2,135	61	107.1	0.964
....	650,000	806.2	475	720	0.0168	1,983	61	103.2	0.929
....	600,000	774.6	450	680	0.0175	1,830	61	99.1	0.892
....	550,000	741.6	425	640	0.0191	1,678	61	94.9	0.854
....	500,000	707.1	400	600	0.0210	1,525	61	90.5	0.815
....	450,000	670.8	365	550	0.0234	1,373	37	110.3	0.772
....	400,000	632.5	325	500	0.0263	1,220	37	103.9	0.727
....	350,000	591.6	300	450	0.0300	1,068	37	97.2	0.680
....	300,000	547.7	275	400	0.0350	915	37	90.0	0.630
....	250,000	500.0	240	350	0.0420	762	37	82.1	0.575
0000	211,600	460.0	225	325	0.0497	645	19	105.5	0.528
000	167,800	409.6	175	275	0.0625	513	19	94.1	0.471
00	133,100	364.8	150	225	0.0789	406	19	83.7	0.419
0	105,500	324.9	125	200	0.0995	322	19	74.6	0.373
1	83,690	289.3	100	150	0.1258	255	19	66.3	0.332
2	66,370	257.6	90	125	0.1579	203	7	97.5	0.293
3	52,630	229.4	80	100	0.2004	160	7	86.6	0.260
4	41,740	204.3	70	90	0.2525	127	7	77.1	0.231
5	33,100	181.9	55	80	0.3130	100	7	68.8	0.206
6	26,250	162.0	50	70	0.394	79.46	7	61.2	0.184
8	16,510	128.5	35	50	0.641	49.98	7	48.4	0.145
10	10,380	101.9	25	30	1.010	31.43	7	38.6	0.116
12	6,530	80.8	20	25	1.601	19.77	7	30.6	0.092
14	4,107	64.1	15	20	2.565	12.43	7	24.2	0.073
16	2,583	50.8	6	10	4.040	7.82	7	19.3	0.058
18	1,624	40.3	3	5	6.567	4.92	7	15.1	0.045

every three sizes, the diameters double only every six sizes. This is as it should be, since doubling the diameter of a circle does not increase the area by two but by four times; or in other words, the area of a circle increases as the square of the diameter.

In the sixth column from the left-hand side of the table is given the resistance per 1000 ft. for round copper conductors at a temperature of 68 deg. F. Referring to the No. 5 wire, it will be found to have a resistance of 0.313 ohm per 1000 ft., and No. 2, which is three sizes larger, has a resistance of 0.1579 ohm, or approximately one-half that of a No. 5. This is just as it should be, since the cross-sectional area is doubled, which is the same as connecting two equal resistances in parallel. In this case also we must be careful to discriminate between the cross-sectional area and the diameter of the conductor. If the cross-sectional area is doubled, the resistance for a given length is halved, but if the diameter is doubled, such as increasing from a No. 5 to a No. 00, the diameter of the former being 181.9 mils and that of the latter 364.8 mils or approximately double, the resistance will be decreased by 4. The resistance per 1000 ft. of No. 5 copper wire is 0.313 ohm and that of No. 00 is 0.0789, or approximately one-quarter that of the former. This again is as it should be; since the cross-section is increased by four, the resistance should decrease by four, just the same as when four equal resistances are connected in parallel, the joint resistance of the four when connected in parallel is equal to that of one divided by four.

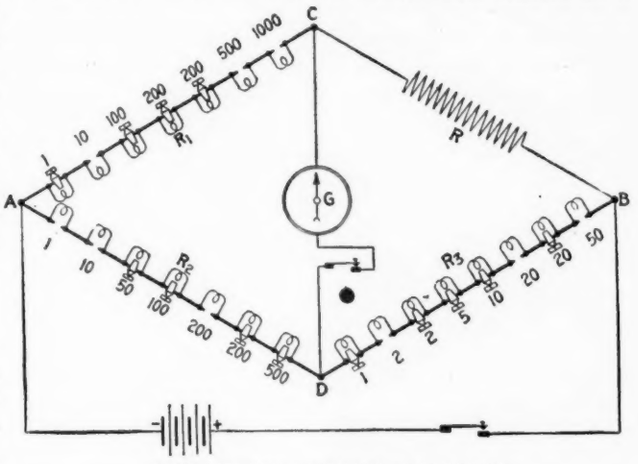
Wire Table Worked Out From No. 10

Referring again to the No. 10 wire, it will be seen to have a resistance of approximately one ohm per 1000 ft. Remembering that the cross-sectional area doubles or halves every three sizes and that the resistance for a given length varies as the cross-sectional area, an approximate table of the resistance per 1000 ft. of round copper can be worked out. The same is true of the weight. No. 10 bare copper weighs 31.43 lb. per 1000 ft.; No. 4, which is six numbers above No. 10, has approximately four times the cross-sectional area and weighs four times as much, or 127 lb. per 1000 feet.

Where wires are pulled into conduits, they are usually stranded except in small sizes, and even then it is good practice to use stranded conductors as they are less liable to be broken and cause trouble after they are installed. The three right-hand columns in the table give number of strands used to make up the conductor, the diameter of each strand and the outside diameter of the conductor bare. It will be seen that the diameter of a stranded conductor is somewhat greater than that of a solid wire of the same cross-sectional area. For example, the outside diameter of a 250,000-cir.mil solid conductor is 500 mils, as given in the third column from the right, while the outside diameter of the same conductor stranded is 575 mils. This is due to the space between the strands.

A solid conductor can be measured with a wire gage, but not so with a stranded conductor. The size of the latter may, however, be determined by measuring the diameter of one strand in mils with a micrometer and squaring this diameter and multiplying the product by the number of strands. For example, a No. 2 conductor is made up of 7 strands 97.5 mils diameter. The square of the diameter is $97.5 \times 97.5 = 9505.25$ cir.mils. The conductor is made up of 7 strands, then the total cross-sectional area is $9506.25 \times 7 = 66{,}544$ cir.mils, against 66,370 cir.mils given in the table for a No. 2 conductor.

The two columns under the heading "Allowable Carrying Capacities of Wires" gives the allowable load in amperes that may be placed upon a copper conductor with a rubber insulation on the wire covered with one, two or three cotton braids, also for conductors that have a weather-proof or a fireproof insulation such as asbestos. These carrying capacities have been established by the National Fire Protective Association and are based upon the current that the conductor will carry indefinitely without increasing in temperature to where it will cause the insulation to deteriorate, and no conductor should be loaded beyond this point. It will be seen that the carrying capacities given for rubber-covered conductors are much lower than those for other insulations. This is because rubber deteriorates at a



WHEATSTONE BRIDGE DIAGRAM

lower temperature than other insulations and also because all conductors installed in conduit or molding must have a rubber covering. When so installed, a conductor cannot dissipate the heat so rapidly as when installed in the open. The carrying capacities given in the table work out all right for short distances, but when an attempt is made to load the conductors up to these capacities for distances over 500 ft., it will be found that in many cases the volts drop becomes excessive. Therefore, it becomes necessary to base the size of the conductors on an allowable voltage drop and not the allowable capacities established by the National Fire Protective Association. Of course a conductor so calculated must be at least as large for a given current as given in the table; if not, the size given in the table must be used. The calculation of the size of conductors according to a given voltage drop will be the subject of the next lesson.

In problem 1 of the last lesson the watts taken by the 25-watt lamps are equal to the number of lamps times their rating, or $50 \times 25 = 1250$; the 60-watt lamp, $75 \times 60 = 4500$ watts; the arc lamps, $5 \times 6.5 \times 112.5 = 3656.25$ watts; the 5-hp. motor, volts $\times$ amperes $= 225 \times 18 = 4050$ watts; and by the 10-hp. motor, $30 \times 225 = 6750$ watts. The total watts, $W = 1250 + 4500 + 3656.25 + 4050 + 6750 = 20{,}206.25$; total kilowatts $= \frac{W}{1000} = \frac{20{,}206.25}{1000} = 20.2$; total electrical

horsepower $= \frac{W}{746} = \frac{20{,}206.25}{746} = 27.1$. The kilowatt-hours equal the kilowatts $\times$ time in hours, in this problem $20.2 \times 3.5 = 70.7$.

Problem 2 is shown in the figure, and the value of $R = \frac{R_3 R_1}{R_2} = \frac{72 \times 1510}{211} = 515$ ohms.

The study problems are: (1) If the resistance of a 400-ft. conductor 65,000 cir.mils in cross-sectional area is 0.45 ohm, find the resistance of 1000 ft. of conductor made of the same material but 32,500 cir.mils cross-sectional area.

(2) A round conductor 750 ft. long and 350 mils diameter weighs 168 lb.; find weight of a conductor made from the same material 1200 ft. long and 922 mils diameter.

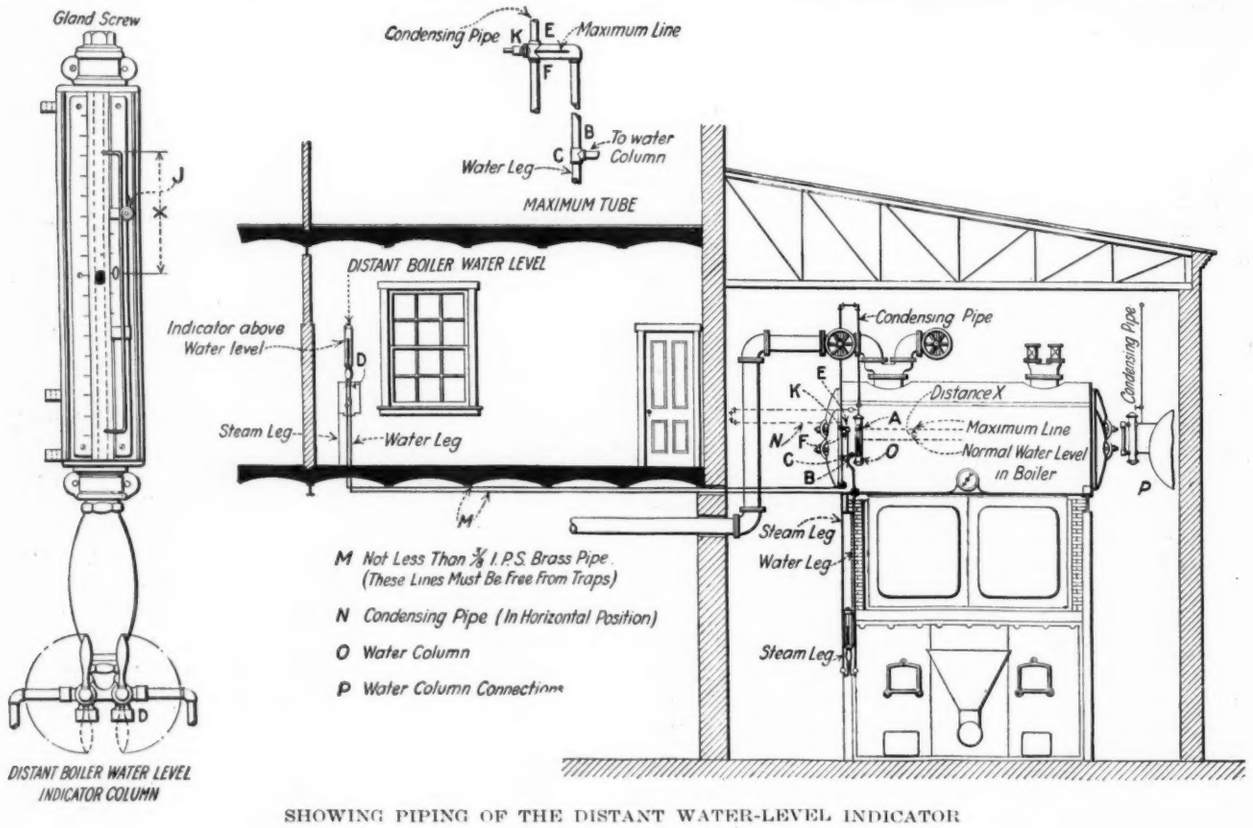
Distant Boiler Water-Level Indicator

It is the usual practice to place a steam gage in the engine room, and doubtless a boiler water-level indicator would be as commonly used were it generally known to be so convenient to install. Such an indicating device is made by the Pneumercator Co., New York.

This water-level indicator operates on the principle of a U-tube. In this case, however, one glass tube is placed inside of the other and the instrument is put in a metal casing that may be placed at any desired position convenient for observation. On the face of the casing is a scale and a maximum pointer. This pointer is set above the normal, or zero, graduation on the scale at a distance equal to the distance X between the maximum line on the maximum tube and the level at which it is desired to carry the water in the ordinary water gage glass. The scale is adjusted by means of a scale-clamping nut J until the maximum pointer is opposite the water level in the outer glass. A colored-glass float indicates the water level in the boiler with reference to the maximum line of the maximum tube, which line is indicated by the water level in the outer glass tube.

The correct registration of the U-glass depends on what is termed the maximum tube K, made with four connections (see enlarged view). This member is set with the maximum tube on a level with the top of the water glass A, as shown. The pipe B is connected at or below the regular water-column connection. The water-leg from the maximum tube is connected to the right connection of the indicator column at D, and the condensing pipe E is connected to the water column at or above the top of the water-column connection to the boiler. The condensing pipe is between 5 and 6 ft. long, and if headroom is lacking, it may be placed horizontally, as at N, in which case it is placed above the maximum tube. The other leg of the condensing tube is connected to the steam pipe of the water column. The steam-leg F from the bottom outlet of the maximum tube is connected to the left connection of the indicator column.

Any condensation in excess of that necessary to keep the water level with the maximum line in the maximum tube flows back to the boiler through the connection to the water column at C, the water remaining in that pipe at the same normal level as carried in the gage-glass. The water in the opposite leg F will be at the maximum water level. These two water levels, normal and maximum, are communicated to the water-level indicator, the colored-glass float in the inner tube indicating the water normally carried in the boiler.



SHOWING PIPING OF THE DISTANT WATER-LEVEL INDICATOR

Editorials

Boiler Room Labor

PROSPERITY brings its troublesome shortages as well as its exuberant rewards. The impetus given certain numerous industries by our deep determination to conduct the war on a scale justified by our abundant means and our aroused patriotism has created wage and hours-of-labor conditions in these industries which irresistibly appeal to labor employed in other and less urgent fields. Women may be seen in overalls and jumpers doing track work on one of the great railroad lines, yet it is common talk along that line that there are men aplenty if the railroad will pay the wages they ask. A brewer building a large addition to his plant paid out of his pocket the difference between what labor asked of contractors doing the work or contributory to it and what the employers were willing to give. Time to the brewer was valuable.

The Erie Railroad lately announced its intention of putting on female labor for its track systems. The wage question was likely the chief determining factor in prompting the move. Men can get such high wages in certain industries in some sections of the country that if engaged in other fields it is difficult to keep them unless the wage is increased enough to be at least competitive.

Broadly speaking, the market today is a sellers' market. And this is as true of labor as of commodities. There never was, perhaps, a time when boiler-room labor, suitable in character, was as difficult to get and as precarious to maintain, as at present. In parts of New England, aye, all of it, the situation is aggravating to the extreme. Already there are signs of forthcoming urgent calls for all machinery that will displace labor in hand-fired plants. This is a true indication of the reality of the bad outlook. Heavy investments are not made on snap judgment only. New York City is in a bad way as regards boiler-room labor. One of the largest and busiest hotels in that city has had its service threatened more than once by labor difficulties in the boiler room.

With even unskilled labor able to get higher wages than all but very exceptional boiler rooms are and have been paying, there seems little hope of meeting the emergency except by increasing the wages. And the employer should have in mind that it is not "welfare" the men want, but money.

The trouble is not confined alone to firemen. The coal shortage at plants, due chiefly to transportation difficulties, has made it necessary to do more trimming in the bunkers than circumstances have compelled in many years. The man who has done it himself knows that trimming coal is a most disagreeable and tiring job. With the wages paid in other industries the men quit, flatly refusing to do the work, and this in some plants, after promises of higher wages. Water tenders who had been with one large plant for fifteen years and more, found other labors more lucrative and left.

Electricity in Steel Making

PROBABLY no other application of electricity has made such rapid developments as that of the electric furnace to the steel-making industry. In a paper, "Factors Relating to the Economical Generation and Use of Electric Power in the Steel Industry," by Brent Wiley, presented at the eleventh annual convention of the Iron and Steel Electrical Engineers, an abstract of which appears elsewhere in this issue, it is set forth that on Jan. 1, 1916, in the United States there were only thirty-six electric furnaces for steel making, having a total capacity of approximately 191 net tons and requiring 40,000 kilovolt-amperes at ninety-per cent. power factor. By Jan. 1, 1918, it is estimated that the installed electric-furnace capacity in steel mills will have reached approximately one thousand net tons and will require 230,000 kilovolt-ampere generating capacity at ninety-per cent. power factor. This growth of the electric furnace can be considered nothing short of phenomenal, and no doubt the stress placed upon the steel industry by the war has had its effect.

The application of electric motors to the main-roll drives has been equally phenomenal, increasing four hundred per cent. during the last five years. It is estimated that the total installed capacity of electric motors on main-roll drives by Jan. 1, 1918, will be 690,000 horsepower and will require approximately 345,000 kilowatts generator capacity. Add to this the capacity required for the 1,200,000 horsepower of auxiliary motors, and the importance of electricity in the steel industry is at once evident.

The result of this extensive electrification has brought about many remarkable improvements in the economical generation of power in the steel industry. The power plants of the earlier periods used to supply auxiliary motors and lights usually consisted of 250-volt direct-current generators ranging in capacity from 200 to 750 kilowatts, driven by slow-speed noncondensing engines. With these equipments thirty-five pounds of steam per kilowatt-hour was considered good practice. The reversing engines used to drive the main rolls required about fifty pounds of steam per brake horsepower-hour and also required a boiler plant near the engine. The introduction of electric drive on the main rolls has made possible the concentration of the power plant in the most convenient location and the generation of power by large economical gas engines or steam turbines from which it can be economically transmitted to the various drives about the mills. The beneficial effect of this change is shown by the fact that seventeen steam turbines furnished by one of the large electrical manufacturers of this country to the steel industry within the last eighteen months averaged 4300 kilowatts capacity, the largest of which was 15,000 kilowatts. The use of such units makes it possible to generate power under conditions that compare favorably with the best central-station practice, and instead of the early-day

water rate of thirty-five and fifty pounds per kilowatt-hour, rates of thirteen to fifteen pounds are easily possible today.

In addition to this the economical utilization of the gases from the coke ovens, blast furnaces and waste gases from openhearth and reheating furnaces has been made possible. From the experience gained by steel plants during the last several years in the generation of steam from boilers utilizing the heat from the waste gases from openhearth furnaces and reheating furnaces, as pointed out by Mr. Wiley, "It seems probable that the steel plant of the near future, consisting of coke plant, blast-furnace, openhearth and rolling-mill departments, will be designed so that the several advantages offered by each phase of heat economy will be so coördinated that no fuel will be burned under boilers direct, and in addition to furnishing all the power required by the plant operation, a fair percentage will be available for sale."

The National Welding Council

AUTOGENOUS welding entered upon what is bound to be a fruitful period when recently in the Engineering Societies Building, New York City, committees of various societies and manufacturers met and formed the National Welding Council. All the industries were represented, together with the insurance companies and the constituted authorities, such for example as represented by J. C. McCabe, safety engineer for the City of Detroit.

The purpose of the National Welding Council is, in the beginning at least, divided into four divisions, to accomplish the following ends: Uniformity of design of pressure vessels to be autogenous welded; licensing of welders for pressure-vessel work; research to determine an infallible test that will reveal unsafe welds, and fourth, to investigate the microstructure and physics of welds. As autogenous welding is so attractive on account of both the cost and the time of doing such work, the development of the art as applied to pressure vessels suffers because engineers who represent the public as well as private interests cannot be certain of the safety of an autogenous weld. The frank statements by Mr. McCabe, and by the insurance interests represented at the meeting by T. T. Parker, of the Fidelity and Casualty Co., and J. G. Shaw, of the Travelers Insurance Co., were most commendable. These gentlemen gave the welders to understand that until some reliable tests that would enable one to determine the safety of a weld had been found, they would not permit of the use of welds in pressure vessels subject to tension. This also is the attitude of responsible engineers, many of whom have applied welds to pressure vessels, that are unlikely to rupture or other accident, and which, if ruptured, will not cause serious damage to surrounding property or loss of life.

One of the first duties of the National Welding Council will be to gather in comprehensive form the data now available relative to welding and to the testing of welds, as well as to the microstructure. This is highly commendable for the reason that considerable is now known about welding, and the council, by properly compiling and arranging the data already at hand, will save itself considerable research work.

While of course it will take some time for the council to make important discoveries, the movement is the most commendable so far set on foot either in this or in any other country to develop the art of autogenous welding so that it may be safe as applied particularly to pressure vessels.

"The Conquerors"

THE special publication got out by the Cleveland Engineering Society, notice of which is to be found on another page of this issue, is probably as unique in its concept as in its caption, "The Conquerors," which is the title of the painting by Jonas Lie, and the property of the Metropolitan Museum of Art, a copy of which appears in the publication as a frontispiece, illustrating the famous Culebra Cut on the Panama Canal. This is used as stated, "to contrast the work of the American engineer and that of the stout old conquistador who, centuries ago, fought his way across the Isthmus to the discovery of the Pacific, for Balboa crushed savage human foes; the engineer, with the aid of medical science, conquered disease, a far more deadly enemy. Balboa brought bloodshed and ruin to the natives of the Isthmus; the engineer brought prosperity and peace. Balboa aimed to monopolize the Pacific and the lands it bathes; the engineer united two oceans by a world-free waterway. Balboa left no trail; the trail of the engineer will endure for ages. The conquistador hungered for loot and selfish gain; the engineer builded that men might live and profit by a greater freedom of the seas. Conquerors both, which was the greater?"

The masses need to know more of the work of the engineer, since it is a notorious fact that vast sums are expended annually in unprofitable work, because it is not based on sound engineering knowledge or principles or is not so carried out. Who then can impart such information except those in possession of it, and how can it be imparted except in the language of the public? As well expect the public to learn a foreign language in order that it may read something on an indifferent topic.

A New England concern had a contract for coal at something over four dollars. The contractor failed to keep up his end, and the concern was obliged to go into the market and compete for its supply, paying as high as eleven or more dollars per ton. Just as soon as the Government fixed the price at $2.20 per ton, the New England concern which had agreed to pay over $4 began to be flooded. Bunkers and yard storage are full, and the tracks between them and the coal mines are still obstructed with cars of coal which the contractor is scrambling to unload at the price contracted for before the Government took a hand. Where was all this coal before?

The A. S. M. E. Boiler Code has made another step toward universal adoption in its acceptance by the Board of Boiler Rules of the State of New Jersey for new installations. If every state would adopt it to this extent, every boiler that went out of use would be one less nonconformant and every year would bring us positively nearer to nation-wide uniformity.

Correspondence

Overloads in Overgrown Plant

When the advent of the European War gave American industry the greatest boom in history, the American Rolling Mill Co. seemed to be in excellent condition to meet the situation, having a new and modern plant with room for extensive expansion and a power plant with a large reserve capacity, but the orders came in such volume that many of the departments had to be enlarged and new forging and machine shops built to take care of the shell orders.

These enlargements affected the power plant, necessitating the installation of many new machines and increased loads all round. There were, before extension began, ten 500-hp. rated vertical water-tube boilers with stokers to supply steam for one double, reversing, blooming-mill engine of 15,000 hp., one single, Corliss, bar-mill engine 5000 hp., two air compressors, two duplex pumps and the generating plant, to be described later. The boilers, rated at 5000 hp., were being operated at an average load of 2700 hp., or 54 per cent. of rating.

Boiler Horsepower Demand Increased

In two years, January, 1915 to January, 1917, the average boiler horsepower demand jumped from 54 to 142 per cent. of rating. Since the new installations added only about 2000 hp. to the load and the increase in electric load was less than 600 kw., it may be seen that the principal increase is the extra loads on the old machines. The load on the blooming-mill and bar-mill engines, aggregating 20,000 hp., is extremely variable and may be thrown on or off at any time; therefore, the boilers are overloaded to that extent only momentarily during some of the peak loads.

This condition could have been relieved by new equipment, if obtainable; but it is impossible to get deliveries on power-plant machinery in less than a year's time, so every effort is being made to keep the plant running until the new equipment is installed. All of the load has been handled with the exception of a few days in the early part of 1917, when the boilers were unable to supply steam enough to operate the entire plant; but it is necessary that the steam machinery used directly in the rolling and forging operations should be kept running. Therefore, part of the electric load in the finishing department was cut off.

The situation is aggravated by the poor quality of the coal obtainable, and Roney stokers are not well adapted to the use of lower-grade coal. During the day, when the load is greatest, it requires three men to keep the grates clean and free of clinkers.

In January, 1915, the average load on the three generators was 2280 kw., and in January, 1917, it was 2840 kw. The low-pressure turbo-generators are operated by exhaust steam at about 1 lb. gage pressure and cannot be loaded above their rating of 1500 kw. each. A 6-in. live-steam line runs to each of these turbines and is used to supplement the exhaust steam when necessary. The high-pressure turbo-generator set can be run at about 100 per cent. overload (3000 kw.) for short periods, making a total available capacity of 6000 kw., if the necessary steam could be supplied. It sometimes happens, however, that the heaviest electric loads occur at the same time as the heaviest steam demand from other parts of the plant, so that a part of the electric load has to be cut off. The electric load is extremely variable, because a large part of it is used by traveling cranes and rolls operating intermittently. A new Westinghouse turbo-generator of 3800 kw. capacity is being installed, designed to use both high- and low-pressure steam. It is well adapted to the conditions and being new and higher in efficiency than the older machines, it should do a great deal to tide us over until new boilers can be put in.

J. K. Rice.

Middletown, Ohio.

Running Ammonia Compressors in Parallel

Owing to continued growth and frequent additions to the establishment, the management of a small packing house was confronted with the problem of adding more refrigerating equipment. The old plant consisted of three compressors, two of 50 tons' and one of 35 tons' capacity.

The chief engineer was asked to recommend the size and make of machinery required, for further consideration by the management. This being a little out of his line, he invited me to come over to the plant and help him out in estimating the requirements and specifying what was wanted.

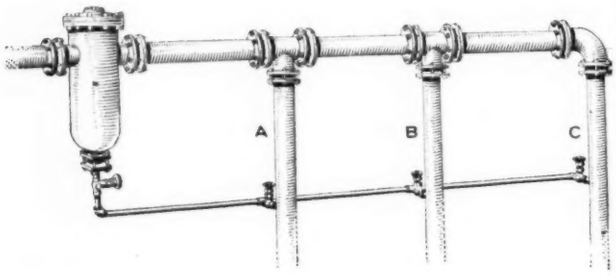
We spent a Saturday afternoon and all day Sunday in going over the problem. The amount of coil surface was estimated and the amount of work required in the different rooms calculated. After we had gone over the work a number of times and obtained approximately the same results every time, the chief was somewhat "flabbergasted" when I told him that he had more capacity than he needed even with the contemplated increase. From a casual inspection of the plant I was unable to account for the discrepancy, but I was sure that the figures were correct.

As I was not very busy for the next few days, I took my ammonia indicator, got a few diagrams from the compressors, and was much surprised at the results. One machine was doing about 60 per cent. of the work, one was doing about 30 and one only about 10 per cent., as figured from the indicator diagrams. The machines were connected to the same suction line and discharged against the same head pressure, although into different condensers. Apparently, the suction pressure should have indicated the same or nearly so in all machines,

but only one machine showed normal suction pressure as indicated by the gage. One of the others showed 2 or 3 in. vacuum and the other something like 13 or 14 in. The chief had told me some time before that he was greatly troubled with the condensers getting air and foul gases in them, and I could readily see the reason after taking the cards. The air simply leaked into the machine through the stuffing-boxes every time they were loosened too much.

The chief stopped to take a look at the cards about this time, and I asked him if he could account for the radical variation in the suction pressure in the different machines. After thinking a few moments, he confessed he could not see why unless it was due to their having to run with the suction valves partly closed on these machines in order to keep them at the proper temperature.

This was news to me, so I went over and tried the valves. On the machine that was doing the smallest amount of work the suction stop valve was nearly shut; it was probably open a half-turn. On the machine that was taking about 30 per cent. of the load, the valve was about a turn and a half open. On the machine that was doing most of the work, the valve was wide open.



SEPARATOR AND CONNECTIONS TO SUCTION LINES

Upon inquiry the chief stated that it was impossible to operate the machines any other way; that if he attempted to open the valves wide, the two machines would freeze up, the packing would leak, the water jackets would freeze up and the machine that was doing most of the work at the present time would run so hot that the discharge header would smoke. To satisfy myself I tried it and found that he was about right.

It did not take long to locate the cause. The machines were connected to the suction line as shown by the large pipes. Machine *A*, on which the suction valve was nearly closed, got the first chance at the suction gas, and practically all the liquid went to this machine when the valve was wide open. Machine *B* took the most of what was left, leaving machine *C* running practically on dry gas.

At first we tried to run the machines on dry gas, by pinching back on the expansion valves until the frost line on the suction line did not come quite up to the machine. This did not work out very well, as the machines ran excessively hot, the valves stuck and the stuffing-boxes gave continual trouble. We carried the load easily with two machines, however, showing that I had been correct in my estimate of the refrigeration required.

After considering several schemes I finally hit on the following arrangement: An old high-pressure steam separator in excellent condition was found that had been taken out some time before, and this was connected in the suction line as shown. The drain from the bottom was piped with a branch to the suctions of the different machines, with a valve in each branch. Any liquid that came back with the suction gas was caught in the separator, and the right proportion to each machine was regulated by the valves in each branch to the suctions. In this manner the machines were run at equal temperatures, no trouble was experienced with the stuffing-boxes and the capacities of the machines were increased so that two handled the load with the new additions. In addition the separator in the suction line caught any slugs of liquid that came along and distributed them evenly to each machine.

Minneapolis, Minn. E. W. MILLER.

Multiple Service Lubricator

A system of cylinder lubrication somewhat similar to that described on page 293 in the issue of Aug. 28, proved unsatisfactory in one case.

A 4-ft. length of 6-in. pipe capped at each end, was placed in a vertical position in the pump pit. A steam lead from the auxiliary headers passed through the top and extended to within an inch or so of the bottom. A $\frac{3}{8}$-in. line connected the upper part with the sight-feed glasses and lubricator connections on the various auxiliaries. It was also provided with a filling plug at the top and a drain at the bottom, apparently a commendable device except for the fact that when changing pumps (feed and fuel), which was done at twelve-hour intervals, the firemen often forgot to close the oil feed, resulting in a waste of oil for the next twelve hours. Moreover, the men seemed inclined to allow the oil to feed faster than they would with an ordinary lubricator, which would have to be refilled when empty. As a result this system was replaced with individual lubricators connected so as not to feed when steam is shut off, and even if not so connected they could not waste more than a pint of oil. The change resulted in a 25 per cent. saving in oil. A. C. MCHUGH.

Del Monte, Calif.

How Is Rope Best Wound on Hoisting Drum?

Replying to Mr. Peirano's inquiry in the issue of Sept. 4, page 334, I do not believe he is starting the first layer off right, which is the cause of the trouble and the reason the rope chafes and wears unnecessarily. I would suggest that he have a steel filling-in piece made the exact size of the cable at one end and gradually tapered to nothing at the other, to go around the drum, and be careful to see that the first layer is put on tight. If the sheave is in line with the center of the drum, it is impossible for the rope to wind any other way than right. In other words, make the drum fit the rope instead of the rope fit the drum.

We have used round cables for the last thirty years and some of them 3200 ft. long have been on for over two years, and during that time we have never had any trouble such as Mr. Peirano describes. We have expert ropemen put the cables on and look after them after they are on, which deserves some consideration.

Mr. Peirano states that there are many other interesting questions relating to hoisting ropes that he would like to have discussed. If he will write these questions to *Power*, as its columns are open to readers and subscribers for any engineering questions, we will all try to help him. Let them come. COLIN F. MCGIBBON.

Butte, Mont

Adjusting an Inertia Governor

The inertia governor, its various adjustments and the changes in regulation that may be secured, have always been interesting to me, therefore the letters, one on page 798, June 12, and two on page 194, Aug. 7, attracted my attention and I offer the following in addition, describing some of the results obtained in operating practice.

Regarding the claim referred to by Mr. Orr that this type of governor can be so adjusted that the engine will run faster under load than when running light and still regulate perfectly, it should be emphasized that it must lack stability when so adjusted for the following reason: The weights of the governor arm are so arranged that the center of gravity is some distance from the pivotal center and the weights *A* and *I* (referring to the original illustration) are made adjustable so that the center of gravity can be established nearer to or farther from the center of the lever pivot. To adjust this type of governor so that it will run faster under load than when running light, it is necessary to bring the center of gravity nearer the center of the arm, but the arm is more nearly balanced, consequently has less control or governing power. This can be accomplished, however, by reducing the weight *A* at the active end of the arm or increasing weight *I*, with a reduced spring tension in either case. Bringing the spring end connection toward the center of the governor arm by the means provided for that purpose will help in securing this adjustment. As to regulating perfectly under these conditions, looking more closely into the matter, it will be found that two conditions—running faster under load and having perfect regulation at the same time—cannot be obtained, for, as the load is thrown on and the speed decreases, the governor arm moves farther than it should, giving a longer valve travel than is necessary to admit sufficient steam to carry the load. This will cause the engine to run faster under load than it did while running light, for a short time; then the governor arm will move toward its other extreme position—if it did not the speed would soon reach the danger point—causing a shorter valve travel again, and not enough steam is admitted to do the work and the speed diminishes; then another swing will take place, and the same cycle will occur. If the load remains constant long enough, the speed may settle down or it may not, but any slight change in load will produce surging again. The greater and quicker the changes in the load the more unstable will be the action.

I have found the following method of adjusting the inertia governor to give excellent results: If the speed of the engine at about one-fourth load is steady but too slow, the tension on the governor spring should be increased; if too fast, it should be decreased. If the speed is not steady, there is likely to be undue friction in some part or parts of the governor mechanism. The pivot pin may be scored or not properly lubricated, the valve-rod packing may be too tight or the dashpot may need oil or adjustment. By disconnecting the spring and moving the governor by hand, the abnormal friction may be readily located.

If additional work put on the engine causes too much drop in speed, shift the end of the spring connected to the governor arm in toward the center of the governor arm and readjust its tension for speed, or remove weight from *A* and reduce the spring tension, or add weight to *I*. To overcome unsteadiness with quick changes in load, either add weight to *A* or deduct from *I*, and adjust the spring by increasing its tension or moving the end outward from the center of the arm.

The same remedy can be applied if the speed changes too much at first and comes back too slow after the change in load, or if the governor arm makes two or three long swings before settling down. The speed of the engine after the load is thrown off should not be more than 2 per cent. above normal; otherwise there is probably a leaky steam valve or insufficient lap.

When this type of governor has once been properly adjusted, any irregularities developed will probably be caused by one or a combination of the following abnormal conditions: Insufficient lubrication, hard-running valve, hard packing in the valve-rod stuffing-box, packing too tight or a scored governor pin.

Albany, N. Y. A. K. VRADENBURGH.

Proper Records Would Have Prevented Motor Trouble

A 110-volt direct-current series motor operated a transfer table in a railroad shop for twelve years without giving any trouble, until one winter the bottom field coil burned out, caused, evidently, by an accumulation of water in the bottom of the frame. The field coil was replaced, and the motor then operated apparently all right again, except that the new field coil heated more than the other and the motor did not seem to handle its load as readily as before. During the summer months, when conditions were such as not to impose overloads, the heating did not interfere seriously with the motor's operation.

The following winter, though, the fields began to heat excessively and finally the condition became so bad that the bottom field coil began to smoke. To aggravate the situation the operator threw snow into the motor. Finally, the shop electrician was called, and without testing the motor for the real cause, he decided that the field coil was short-circuited and upon this decision a bottom field was ordered. After placing the new coil, it was found that the motor barely moved the empty table. So the electrician, having a top field on hand, also changed this one, but without avail. After trying everything in the way of locating the trouble with the facilities at hand, and still not succeeding, an expert was summoned, who worked on the motor for two days longer without finding anything. As a last resort the motor was loaded till it took its normal full-load current, and the fields were then tested for drop of potential through each coil. This test showed a drop of 95 volts across the bottom and 5 volts across the top coil. This of course indicated that there was something wrong with the bottom coil, as there should not be such

a high drop through the field coils of a 25-hp. series motor. The loss of potential in both the field and armature should not exceed 9 per cent. of the voltage the motor is designed to run on.

The bottom field coil was again removed and was opened up. The coil was lead-covered, and over half of this covering was melted off from the excessive heating of the coil, and the tape underneath was scorched to brittleness. The top field was also bared, but just enough to get the size of the wire. It was found that the bottom coil was wound with a single No. 6 wire and the top coil with two No. 4 wires in multiple. There was not another coil of the same size wire as the top field at hand. However, we had the correct size in stock and decided to wind another coil. After placing the new field coil and trying out the motor, we found that it still did not pick up the load the way it should, so started to investigate by writing to the manufacturers, and learned that the motor, as originally designed, was a 500-volt street-railway motor. Later on the manufacturers found that they could adapt it to stationary service, so made provisions on this pattern of frame for legs, and wound its armature and fields for 250 volts. When a 110-volt machine was required, they wound the armature for this voltage and connected the 250-volt field coiled in multiple. After finding this out and connecting the field coils in multiple, the motor operated as it should.

When the motor was first installed, it was connected up right, as the man who did the installing had the proper instructions. When the next man came along, twelve years later, he knew nothing about the history of the motor, consequently the motor was connected up wrong. All the unnecessary expense in obtaining new field coils, loss through delay, etc., could have been avoided—about $250 could have been saved—if a careful record had been kept of the motor. Sometimes even the manufacturers make mistakes in cases like this, where they have the same type of motor for different voltages. From now on we shall keep a careful record and history of each motor in our plant.

Winona, Minn. V. T. KROPIDLOWSKI.

Location of Oil Burners

The proper location for oil burners varies with different types, and it is of considerable importance that they be placed in the best position, as failure to do so may cause trouble.

In one case a single-drum "Franklin" boiler was equipped with two burners of the "fantail" type in which the oil and steam leave the burner tip through two long, narrow, parallel slots, the oil slot located above that for the steam. In this particular burner the oil slot was enlarged by drilling small holes, four or five in number, causing considerable tendency to increase the flame length, as the oil emerging in a solid stream was not readily broken up by the steam. The burners being of the "rear-shot" type, the tips were placed in small recesses in the front furnace wall and the air was admitted through checkerwork beginning several inches forward of the tips.

No trouble was experienced with burned or blistered tubes, but believing the atomizing type of burner to be more economical, they were substituted. The oil issues from these burner tips through a slot above the steam slot, but at right angles to the steam, atomization taking place very close to the tip. The new burners were placed in the same position as the old ones, but within a week three tubes were lost, having been burned through at a point about five feet from the front water-leg. As the boiler was clean, the cause was not apparent, but after retubing, the same thing occurred again after several weeks run, and this time one of the new tubes was burned.

Believing that the location of the burners had had something to do with the trouble, they were moved forward three inches and the checkerwork was so arranged as to permit some air to enter back of the tips, the idea being that the wide short flame had been lifted upward by the force of the air current through the checkerwork and, playing directly upon the tubes, had caused them to burn. It was believed that air taken in behind the burner would rise and form an insulating film over the forward part of the flame pass, thus protecting the tubes, and that by moving the burners forward the velocity of the jet would be enabled to resist the force of the entering air current. Results have substantiated this belief, as no further trouble from burned tubes has been experienced. A. C. MCHUGH.

Del Monte, Calif.

Motor Made a Rumbling Noise

The rotor bars of the first squirrel-cage type of induction motors were effectively insulated from the core slots and were soldered, bolted or riveted to the end rings. Later it was determined that there is no advantage in so carefully insulating the bars from the core as the rotor circuits are sufficiently well defined without such precaution, consequently, in a number of the modern types no insulation is used on the bars. The original methods of fastening the bars to the end rings were quite satisfactory, but in many of the modern types of machines the end rings are either cast on or welded to the bars. One of the weaknesses of the older form of construction, when subjected to frequent startings and to continuous overloads, is demonstrated by the following instance:

An operator complained that a large three-phase induction motor would emit a rumbling noise when it was started, but that the noise would cease after the motor had acquired considerable speed. Thinking that the motor might have low bearings, they were replaced, but this did not help matters. Investigation disclosed that the motor was about fifteen years old and that it always had been on severe duty which was characterized by frequent starting. As a result of the continuous abuse, the insulation of the rotor bars had disintegrated so that the bars were quite loose in the slots. The working back and forth of the bars had loosened the end connections, and this so impaired the conductivity of the rotor circuits that the motor would start in a slow impulsive manner. However, the imperfectness of the rotor circuits did not appear to affect the speed when near synchronism, even when a heavy overload was applied. After the proper repairs were made on the rotor, there was no further complaint of noise or of sluggish starting. E. C. PARHAM.

Brooklyn, N. Y.

Inquiries of General Interest

Breeching Temperature as Indication of Efficiency—Does a low breeching temperature always indicate high boiler efficiency? L. W.

Not necessarily, as a low temperature of the discharged gases may be due to deficient air supply that causes the volatile matter in the fuel to pass off unburned, and while this may lower the breeching temperature, it also lowers the efficiency.

Generator's Direction of Rotation Changed—If the direction of rotation of a compound-wound direct-current generator is changed, what connections must be changed in order to get it to build up again? T. D. T.

When the direction of rotation of a compound-wound direct-current generator is reversed, both the series- and shunt-field winding leads or the armature leads will have to be crossed. Sometimes either one cannot be done conveniently; in such a case shift the brushes around the commutator one pole space. In a shunt machine cross the field leads or shift the brushes one pole space.

Factor of Evaporation with Superheated Steam—What would be the factor of evaporation for operation of a boiler plant where steam is generated at a pressure of 150 lb. gage and 100 deg. F. superheat, from feed water at 108 deg. F.? A. W. L.

Unless otherwise provided, a combined boiler and superheater should be treated as one unit, and the equivalent of the work done by the superheater is to be included in the evaporative work of the boiler. A pound of steam at 150 lb. gage, or about 150 + 15 = 165 lb. absolute, when superheated 100 deg. F. contains 1252 B.t.u. above 32 deg. F., and as the feed water would be 108 — 32 = 76 deg. above 32 deg. F., for conversion into steam, each pound of the feed water would receive 1252 — 76 = 1176 B.t.u. Evaporation of a pound of water from and at 212 deg. F. requires 970.4 B.t.u.; and, for the conditions stated, the equivalent evaporation from and at 212 deg. F., or factor of evaporation, would be 1176 ÷ 970.4 = 1.2118.

Different Sized Cables with Balanced Lift—In winding and unwinding balanced cages from the same 5-ft. diameter drum, where the lift is 300 ft., what would be the difference in height of landing the cages if one cage is suspended by a 1-in. diameter cable and the other by a 1¼-in. cable? C. B.

For ¼ in. difference in diameter of the cables, one revolution of the drum would take up or unwind about ¼ × 3.1416 = 0.7854 in. more length of the larger than of the smaller cable. To lower the cage suspended from the 1-in. cable through a height of 300 ft. would require

$$\frac{300 \times 12}{[(5 \times 12) + 1] \times 3.1416} = 18.79$$

revolutions of the drum, and the cage suspended from the 1¼-in. cable would be landed 18.79 × 0.7854 = 14.76, or about 14¾ in. higher than the level from which the other cage had been lowered.

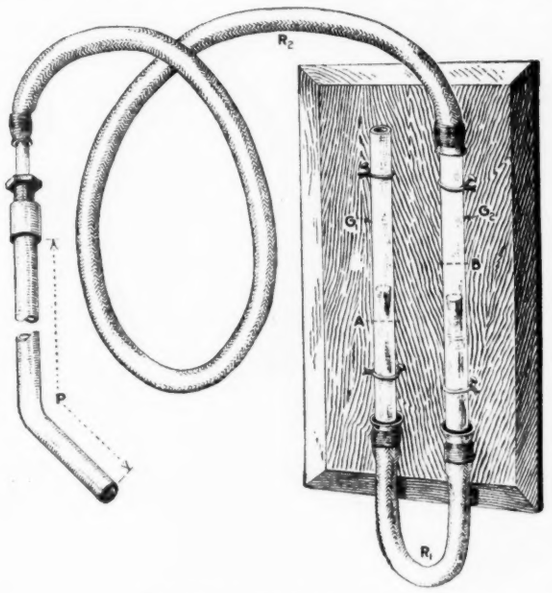
Reversing Engine with Same Angular Advance of Eccentric—If the eccentric of an engine is set with an angular advance of 28 deg. and it is desired to change the direction of rotation of the engine, how many degrees should the eccentric be moved and in what direction so that the angle of advance will be 28 deg.? C. W. O.

Angular advance refers to the angle that the eccentric is more than 90 deg. ahead of the crank. Therefore angular advance of 28 deg. would signify that the eccentric is 90 + 28 = 118 deg. ahead of the crank, measuring in the direction of rotation. By turning the eccentric backward 118 deg., it would be coincident with the crank, and moving it backward another 118 deg. would place the eccentric in position for reversed rotation of the engine with the same angle of advance as before. Hence the total backward movement of the eccentric should be 2 × 118 = 236 deg., and the new position would be the same as though the eccentric were moved forward through an angle of 360 — 236 = 124 degrees.

Testing Force of Draft—How can measurement be made of the force of draft in the furnace and other parts of a horizontal return-tubular boiler setting? L. B. R.

The force of draft over the fire and in the passages of the furnace gases may be measured in inches of water by means of a U-tube pressure gage. This consists of a glass tube bent in the form of the letter U or two glass tubes connected at their lower ends set in an upright position and partly filled with water. One leg of the U is left open to the atmosphere and the other leg is connected with the space where the force of draft is to be obtained. The force of draft is then indicated by the difference of level of the water in the legs of the U tube.

A draft gage can be constructed as shown in the sketch. G_1 and G_2 are two ordinary gage glasses mounted on a board and joined at their lower ends by a piece of rubber tubing R_1. One of the columns of the U-tube, as G_1, has its upper end open to the atmosphere, while the upper end of



TESTING FORCE OF DRAFT

G_2 is connected by rubber tubing R_2 and a nipple to a piece of ½-in. pipe P about 6 ft. long, bent over at the open end. Water is poured into the open end of G_1 until it stands about halfway up the length of both glass tubes. All joints should be sealed perfectly air-tight. Then when the open end of P is inserted in a flue or passage where the force of draft is to be obtained, the atmospheric pressure being greater than the pressure of the furnace gas, the water is depressed in the tube G_1 as to A, and rises in G_2 as to B. The difference of level, usually only a fraction of an inch, will be the measure of the force of draft. By turning the pipe P in different directions, its bent open end may be presented for measuring the force of draft in different directions or parts of the flues and passages.

Economical Generation and Use of Electric Power in the Steel Industry*

By BRENT WILEY

The broad problem of economical power generation and application in the steel industry today is considered, and the tendencies and possibilities are discussed.

WHILE it is true that even a decided improvement in the economy of the power required to produce a ton of steel in the finished state would vary its total cost only a fraction of 1 per cent., as considered from past practice, this item is fast becoming a more serious one. The supply of natural gas is giving out rapidly in many localities which formerly provided a cheap fuel, and the price of coal is increasing very fast. The question of transportation, together with greater demand for coal, has added serious problems to the plant-management list. Thus, today added effort is being made to utilize every heat unit to the best advantage, and every steel plant will do well to review its conditions thoroughly, to see that its practice is giving the best results in this respect; for in order to meet the rapidly increasing demands of the steel industry successfully, electric-power engineering must follow a broad policy.

During the earlier periods the plant area was rather limited. The power station usually consisted of two or more 250-volt direct-current units, ranging from 200- to

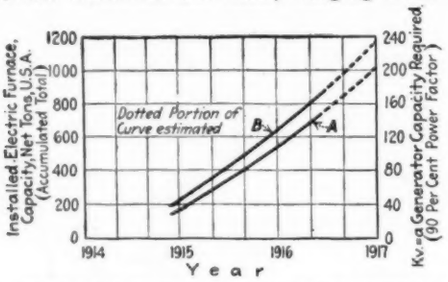


FIG. 1. ELECTRIC-FURNACE CAPACITY INSTALLED IN STEEL MILLS IN U. S. A.

Curve A—Electric-furnace capacity. Curve B—Generator capacity required for the furnaces, Curve A

750-kw. capacity. These were driven by slow-speed engines, operating in many cases on 125-lb. steam pressure noncondensing, at speeds ranging from 125 to 250 r.p.m. A steam consumption of 35 lb. per kilowatt-hour was considered a fair practice. No comprehensive design of power plant was considered necessary, and as a result the station just grew. Even today the power plants, in general, are composed of a number of comparatively small and inefficient units.

One of the first factors which developed marked improvement in power-plant engineering as relating to larger mills was the rapid growth of steel capacity. With the increase in size of plant and amount of power required, alternating-current power was adopted approximately twenty years ago. The higher voltage greatly simplified the transmission problem, and the larger capacity and high-speed type of generating units gave increased economy.

The steel-making capacity of the mills of this country has doubled within the last twelve years, being at present 48,000,000 tons per year (as will be completed by Jan. 1, 1918). The output in 1916 was approximately 43,000,000 tons. This capacity requires approximately 1,200,000 total installed horsepower of auxiliary motors, which includes power for the blast-furnace department. To supply this auxiliary motor capacity, 180,000-kw. generator capacity is required (spare units not included). With the advent of motor drive for the main rolls, which became a real factor approximately ten years ago, the electric power plant began to receive serious consideration by the management of those plants directly interested in this application. For every horsepower of main-roll motor drive, it requires approximately 0.5 kw. of generating capacity, which is about three times that necessary for a horsepower of auxiliary motors. The total installed horsepower of motors for main-roll drives in this country Jan. 1, 1918, will be approximately 690,000. During the last five years the total horsepower installed increased 400 per cent.

A third factor which is rapidly increasing the demand for electric power in the steel industry is the electric furnace. There were 36 furnaces of approximately 191 tons net capacity installed in the United States Jan. 1, 1916, requiring about 40,000 kv.-a. 90 per cent. power factor generating capacity. Estimates made for the last half of this year, based on sales made to July 1, 1917, show that the total installed electrical-furnace capacity will be approximately 1000 tons, requiring 230,000 kv.-a. 90 per cent. power factor generating capacity. The growth of the electric furnace and the power requirements are shown in Fig. 1.

The curves given in Fig. 2 show the growing demand for electric power, and it is of particular interest to note the unusual increase given for the last two years. This rapid growth in the scope and application of electric power in the steel industry and amount required makes the generation of power a more and more important question, particularly from the viewpoint of economy. The broad problem of economical power generation for practically every steel-plant process today includes the study of one or more of

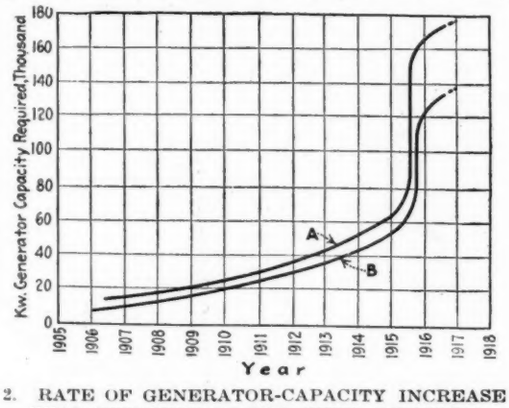


FIG. 2. RATE OF GENERATOR-CAPACITY INCREASE PER YEAR REQUIRED IN THE STEEL INDUSTRY

Curve A—Total generator capacity as furnished by steel-mill and central-station companies (spare generators not included). Curve B—Generator capacity of steel-mill power plants only.

the following points: Proper utilization of the heat units of coke-oven gas from the coke plant, blast-furnace gas in pig-iron production and waste gases from openhearth and reheating furnaces.

Coke-oven gas is used for fuel under boilers for the generation of steam, for openhearth furnace work, reheating furnaces and in a number of cases in gas engines for direct generation of power. Blast-furnace gas is used under boilers and in gas engines to furnish air for the blast furnaces and also electric power for outside purposes.

It seems probable that the steel plant of the near future, consisting of coke plant, blast furnace, openhearth furnace and rolling-mill departments, will be so designed that the

*Abstract from a paper, "Factors Relating to the Economical Generation and Use of Electric Power in the Steel Industry," presented at the eleventh annual convention of the Association of Iron and Steel Electrical Engineers, held in Philadelphia, Penn., Oct. 10-14, 1917.

several advantages offered by each phase of heat economy will be so coördinated that no fuel will be burned under the boilers direct, and in addition to furnishing all the power required for the plant operation, a fair percentage will be available for sale.

Figuring on a basis of modern gas-engine units, 4000-kw. capacity and 10,000-kw. turbo-generators to operate under modern conditions, steam presssure, superheat and vacuum, the same amount of power being generated in both cases and coal at $2.50 per ton is to be used to produce the extra steam power required by the turbo-generator unit, the comparative costs of equipment are as follows:

	First Cost Per Cent.	Operating Cost Per Cent.
Gas-blowing engines—gas-engine-driven electric units	100	100
Gas-blowing engines—turbo-generators (complete engine equipments, including auxiliaries)	60	80

A considerable further saving in first cost and cost of operation can be obtained by the installation of turbo-blowers in the place of gas-engine blowing units, this being approximately 20 and 30 per cent. respectively.

Practice shows that one kilowatt-hour of power can be generated for approximately 230 cu.ft. of gas by turbo-generator units, and by gas-engine units for 190 cu.ft. There are wonderful possibilities for fuel economies in the steel industry, and the next step is to determine how the steam thus produced can be utilized to the best advantage.

In the large majority of cases the greatest amount of work can be performed by generating electric power and using motor-driven mill units.

As a summary of the several factors that warrant the careful consideration of every steel-mill engineer regarding economy in generation and use of power, it may be stated that the general trend of the times is to use the waste gases under boilers as fuel or absorb a large proportion of their latent heat direct—utilize the steam thus produced in large-sized turbines for the generation of electric power and equip the mill universally with motor drive, and for the special steel in particular adopt the electric furnace.

There are many plants that are lacking in such means of economy as have been previously mentioned. Additional electric power means the burning of coal under boilers. As the demands are increasing rapidly, the best policy would be to plan improvements on a comprehensive scale, which would also mean an investment of considerable capital.

The steel-mill power load is becoming more and more favorable regarding amount, load factor and power factor, and consequently is more desirable from the central-station companies' standpoint. The rates for power and reliability are features which are attractive to the steel industry, and many plants are now purchasing power. At least 75 per cent. of electric-furnace load is on central-station lines, and the percentage of main-roll motor loads is increasing rapidly. The future possibilities of greater benefit to both parties concerned are definitely established by the tendency of the times as given in data of Fig. 2.

Establishes a Technical Data Bureau

It is again suggested that more consideration be given to the establishment of a technical data bureau, so that a definite analysis can be made for any plant conditions existing or planned for future improvements. Unnecessarily large safety factors generally result in loss of economy. The various details of electric-power requirements for various types and sizes of mills should be compiled in detail form.

The subjects when to start to electrify and to what extent will motor drive be applied to steel-mill drives should as a rule be considered jointly, for the actual value of motor drive is seldom realized until it is a part of the complete electrification. Thus a broad engineering policy with possibilities for carrying on a plant-wide improvement is worthy of consideration in the majority of mills.

There have been cases where on first analysis the electrification of one new mill showed only a moderate return on the investment. However, when future mill improvements are included in the estimate, the economy of operation is greatly increased. The power-station first cost was materially reduced per unit, the increase of load factor increased the working capacity of the unit of power, thus reducing the proportion of the station's cost.

Quite often it is necessary to consider changes upon very short notice, and if plans have previously been made to include the proper improvements, these can be provided for with less confusion and with the assurance of obtaining the best arrangements.

To show that many plants are planning on a broad and comprehensive basis, a review is given of some of the power-station installations made recently. The average of 17 turbine units furnished, by one of the large electrical manufacturing companies in this country, to the steel industry within the last eighteen months is 4300 kw., and the largest is 15,000 kw. Such additions to a power plant require considerable time for completion, and on account of the urgent demand for additional mills, may prove to be the very factor that would interfere seriously with the construction of the otherwise favorable plan of execution. Furthermore, reserve power is an excellent help to caring for the much-neglected item; obsolescence of power units. Remarkable advance in central-station practice has been made in the last few years along this line. The companies have considered it advisable to prepare for the future on a broad scale, and units of much larger capacity and much greater in number have been installed. The advantage of practical engineering foresight, which makes possible the planning for several years of future improvement, is becoming more and more essential to the development of true economy of operation in every industry.

Convention of Smoke Prevention Ass'n

From Sept. 25 to 27, inclusive, the Twelfth Annual Convention of the Smoke Prevention Association was held in Columbus, Ohio, headquarters and all sessions at the Hotel Deshler. The convention was called to order by President William H. Reid, chief smoke inspector of Chicago, the following officers being present: First Vice President Martin A. Rooney, Nashville, Tenn.; Second Vice President W. L. Robinson, Baltimore, Md.; and Frank A. Chambers, of the Chicago Smoke Inspection Department, secretary-treasurer. Mayor Karb addressed the convention, as did Henry A. Williams, president of the Columbus Chamber of Commerce, and Col. John Y. Bassell, manager of the Columbus Conventions and Publicity Association. Response was made by President Reid, of the association.

Monday morning the convention entered into business sessions for the election of new members and the reports of committees.

Tuesday afternoon Henry Misostow, of the Smoke Inspection Department, Chicago, Ill., read a paper on "Proportioning a Chimney on Fuel Basis." This paper will appear in an early issue of *Power*. Written discussion of the paper was presented by William L. Greeley, of the Alphons Custodis Chimney Construction Co.

Tuesday afternoon the ladies attending the convention, accompanied by several Columbus ladies, enjoyed Pauline Frederick in "Double Crossed."

There followed a report of the Government tests held at the Bureau of Mines in Pittsburgh, by Royce L. Beers.

Wednesday was railroad day, the following papers being read: "The Effect of the Brick Arch on Locomotive Smoke Abatement," by J. T. Anthony, New York City. Written discussion on this paper was presented by F. S. Deveny, of the Baltimore & Ohio R.R., Chicago, Ill. There followed topical discussion on the subject of "Powdered Coal," after which moving pictures showing smoke abatement on the Pennsylvania R.R. at Pittsburgh were shown. "Firing Up Locomotives," by Allen Armer, general foreman, Big Four roundhouse, Columbus, Ohio; and "Government Supervision of Fuel," by Hon. Maurice H. Donahue, judge of the Supreme Court of Ohio, were then read. A practical demonstration of firing up engines at the New York Central roundhouse, Columbus, interested several of the conventioners.

In the evening there followed the banquet and ball at the Hotel Deshler.

A paper on "The Manufacture of Byproduct Coke and Its Effect on the Domestic Smoke Problem" was read by W. C. Ross, of Chicago. There followed a business session and the election of officers, the following being the new officers of the association: President, William H. Reid; first vice president, Daniel Maloney; second vice president, William H. Corbett; secretary-treasurer, Frank A. Chambers.

An abstract of J. T. Anthony's paper on "The Effect of the Brick Arch on Locomotive Smoke Abatement" will appear in an early issue of *Power*.

The following resolution on the conservation of fuels by Federal Government supervision was adopted:

Whereas, Incomplete combustion is causing enormous waste of the natural fuel resources of the country; and

Whereas, This incomplete combustion results from the use of obsolete furnace construction, improperly designed fuel-burning equipment, carelessness and ignorance in operation and wasteful methods of firing; and

Whereas, The United States Government does regulate through a Fuel Commissioner the quantity of fuel allotted to the various industries of the country; therefore, be it

Resolved, That the Smoke Prevention Association assembled in convention at Columbus, Ohio, Sept. 26, 1917, recommends that the supply of fuel be further conserved by the appointment of a Federal Fuel Conservator in each state to regulate the consumption and burning of fuel; and be it further

Resolved, That this association offers the services of the trained combustion experts employed in the various smoke departments of the country, and other combustion expert members of the association, to assist in this work of fuel conservation; and be it further

Resolved, That a committee consisting of William H. Reid, president; W. L. Robinson, second vice president, and W. A. Pittsford be instructed by this association to confer with the proper Government authorities and urge them to take such action as will carry out the spirit of this resolution; and be it further

Resolved, That the secretary of the association be instructed to forward this resolution to the proper Federal authorities, and that a copy thereof be spread on the minutes of this meeting.

Vacancies in Grade of Assistant Civil Engineer, U. S. Navy

An examination will be held at the Navy Department, Washington, D. C., to fill existing vacancies in the grade of assistant civil engineer, Corps of Civil Engineers, United States Navy. All papers and other information required of candidates for the preliminary examination must reach the Bureau of Docks and Yards, Navy Department, Washington, D. C., by noon, Oct. 31, 1917. The vacancies to be filled will number not less than ten. They will be filled by the appointment of candidates successfully passing the examinations. The examination to determine the candidates' professional fitness will comprise:

First—A preliminary examination to determine the candidate's general fitness, based on his collegiate record, testimonials, statements of references and professional experience. Candidates will not be assembled for this examination, but will submit their papers by mail direct to the Examining Board in Washington.

Second—A final examination, including an oral and written examination, to be held in Washington, D. C., and open only to those who have passed the preliminary examination.

Candidates before the final examination will be examined as to physical fitness by a board of medical officers of the United States Navy. If found to be physically unfit, the candidate will not be further examined. The following are prerequisites for consideration:

No candidate over 26 years of age on July 1, 1917, will be eligible for examination. The candidate must be an American citizen; must have received a degree from a college or university of recognized standing, showing that he has satisfactorily completed a course in civil, electrical or mechanical engineering; must have had not less than 14 months' practical professional experience since graduation and must be of good moral character and repute.

Candidates who did not qualify in the preliminary examination held in May, 1917, or who failed in the final examination held in June, 1917, are not eligible for this examination. Candidates who passed the preliminary examination but failed to complete the final examination are eligible for this examination. The fact that a man is married will not militate against his eligibility.

Appointees are commissioned in the grade of assistant civil engineer, Corps of Civil Engineers of the Navy, with the rank of lieutenant (junior grade). This rank carries with it pay and allowances approximating $2500 a year. The highest rank in the Corps of Civil Engineers is rear admiral, carrying with it, including pay and allowances, a remuneration of approximately $9500 a year.

Officers of the Corps of Civil Engineers are detailed to the various yards and stations and to the Bureau of Yards and Docks, Navy Department, Washington, D. C., which bureau has charge of the design and construction of all the public works of the naval establishment on shore as well as the maintenance and repair of existing structures. This corps is a growing one, and its position in the navy organization is one of prominence. New construction authorized and under way aggregates over $100,000,000. Several million dollars is also expended by the bureau annually for the upkeep of naval property. The work is exceptionally varied and offers an attractive field for able and ambitious young engineers.

Refrigerating Engineers' Meeting

The New York Association of the American Society of Refrigerating Engineers held its first fall meeting in Machinery Club, Hudson Terminal, Thursday evening, Sept. 27. A dinner preceded the reading of a paper on "Heat Transmission from Pipes to Air," by C. H. Herter, secretary of the New York Association. Fred Ophuls presided. Mr. Herter's paper was a review of the chief factors developed by many experimenters. William H. Ross, secretary of the society, opened the discussion of making available papers to be presented before the New York Association during the coming winter. Several members expressed a wish to hear a paper on the "Relative Merits of High-Speed Compressor Valves," and requested F. L. Fairbanks, of Boston, present at the meeting, to prepare it, he having done considerable testing of types of these valves. Mr. Fairbanks agreed, but advised that other work would delay the preparation of the paper. "Determining Equitable Charges for Refrigeration Service," "Operation Costs of Electric-Driven Compressors," "Corrosion in Ammonia Condensers," were other subjects on which many desired that papers be presented.

Considerable interest was shown in discussion of the control of humidity in rooms solely by proper coil or cooling surface and temperature. Mr. Herter asserted that, theoretically at least, this was possible at any season of the year. George A. Horn, Mr. Ophuls, Mr. Fairbanks and others questioned the achievement of this in practice without the use of steam coils. The subject appealed to all as of sufficient value to warrant further investigation.

The next meeting will be early in November, the date not yet fixed.

Kansas City Light and Power Co To Have New Plant

Twenty-five acres of land has been purchased on the Missouri River in Kansas City, Mo., by the Kansas City Light and Power Co., on which it will erect a new electric-light and power plant.

Plans for the new station are being drawn by Sargent & Lundy, mechanical and electrical engineers, Chicago. The first section of the main building will be 200 x 266 ft., and the first installation will cost about $4,000,000. A contract has been let to the General Electric Co. for two turbines each capable of generating 20,000 kw. This is the only contract which has been let thus far. The contract for the

foundations will be let in about 30 days and others will follow. The plant, with its first 40,000-kw. capacity and six large boilers, is expected to be in operation by Nov. 1, 1918.

The final plans call for the installation of eight turbines, with a condenser for each, giving a probable total of 200,000 kw. Two big intake tunnels will be built from the plant to the river, the first, 10 x 20 ft., to be installed immediately This will be capable of handling 200,000 gal. of water per minute for the condensers. A discharge tunnel capable of disposing of 400,000 gal. of water per minute from the condensers will be constructed with the initial plant, looking to the future when its full capacity will be required.

The turbines will operate on a stream pressure of 250 lb For the present boiler capacity two chimneys, 15 ft. diameter and 200 ft. high, will be constructed. Ultimately there will be eight of these. Economizers will be installed. The plant will have capacity for storing 100,000 tons of coal, and its ultimate consumption will be about 2400 tons a day. It will be handled by machinery after it reaches the plant.

The switchhouse from which the distribution of current will be handled is to be two stories and basement but a part of the main building. The pumphouse will be just outside of the main building. Sargent & Lundy will have charge of all construction work and installation of equipment.

New Publications

PRACTICAL ELECTRIC ILLUMINATION. By Terrell Croft. Published by McGraw-Hill Book Co., Inc., New York, 1917. Cloth; 5½ x 8 in.; 225 pages; 166 illustrations. Price, $2.

This book treats the subject of electric illumination from the practical standpoint rather than the theoretical, although the author has introduced theory where he considered it essential to an understanding of the practical side of the problem.

The work is divided into nine sections. Section 1 discusses the fundamental ideas of light radiation in common nontechnical terms, explaining the nature of light, how it is probably produced and propagated, how and why it is reflected under certain conditions and how it acts on the human eye. Section 2 deals with the principles and units, embracing such features as photometric units and abbreviations, the laws by which illumination varies, fundamental conception on which the art of illumination is based, the practical significance of luminous intensity, standards of luminous intensity, luminous ratings, illumination calculations, different lighting systems, etc. Section 3 is devoted to a consideration of the different types of reflectors. Sections 4 and 5 cover in a practical way the subject of incandescent and arc lamps. Tables are included, giving the properties of carbon arc lamps, data on inclosed-flame arc lamps and representative arc-lamp data, also the cause and remedy of trouble in arc lamps. Section 6 describes the construction and operation of Nernst, mercury-vapor and tube lamps. Section 7 deals with the principles of illumination design. In this section many useful tables are given on such features as economical densities of illumination in foot candles, lighting sources available, desirable mounting heights and spacing of tungsten lamps, etc. Section 8 treats the various kinds of interior illumination and section 9 exterior illumination. The text is indexed under 344 subheads, and each of the subheads is numbered so that any subject treated may be easily located.

Appearing at a time when the art of illumination has become a science and when not only in the industries but in the home and on the street the great demand is more and better light, this book should go far in filling the needs of those who in any way have illumination problems to solve.

GAS CALORIMETER TABLES

Circular No. 65 of the Bureau of Standards, entitled "Gas Calorimeter Tables," is practically a supplement to Circular No. 48, "Standard Methods of Gas Testing," containing, as it does, correction tables or tables of correction factors for the reduction of barometric heights at various temperatures to inches of mercury at standard temperature (32 deg. F.), charts showing relative humidity by wet and dry thermometer readings ventilated and unventilated, emergent stem corrections for thermometers, and a table of corrections for humidity in B.t.u. to be applied to observed heating values in calculating total heating values of illuminating gas. Proposed record sheets or forms are given in the hope that they will be adopted wherever possible in the interest of greater uniformity in operating methods and records. Full instructions as to their use are given, with one test record completely filled in, from actual practice. This paper is now ready for distribution, and a limited number are available, on written request, from the Bureau of Standards. The regular sale price is 5c. at the Government Printing Office, Washington, D. C.

THE CONQUERORS

The Cleveland Engineering Society has recently brought out a specia. publication entitled "The Conquerors," containing seven well-illustrated articles or papers written by prominent engineers in popular, nontechnical terms as a means of creating general interest in the great work accomplished by engineers ancient and modern. Quoting from the foreword, "its aim is to suggest a means for supplying an important public need. There is a desire on the part of the public for information on engineering subjects and for a degree of familiarity with engineering practice which will permit a fuller utilization of the service which engineers are prepared to give. The satisfaction of this desire is important because it is through the exercise of the functions of the engineer that the resources of nature and of science are marshaled together for the use and convenience of man, and a better understanding on the part of those with whom the demands originate and of the direct and efficient ways in which these resources may be made available will make for a better, freer use of engineering service."

If the engineering profession can, through the medium of a well-conducted magazine, so familiarize the public with fundamental ideas concerning the inception and carrying through of engineering works, it will become more difficult for glib-tongued orators and opportunist politicians to lead it astray with theories and schemes which do little more than increase taxation.

The successful achievement of such a purpose is so great an undertaking that it is only through the coöperation of a considerable portion of the profession that hope may be had for its accomplishment. For that reason coöperation has been sought and found throughout the length and breadth of the land among engineering societies, colleges and practicing engineers. Libraries, museums and publishers have responded cheerfully to requests for data and illustrations. The papers have been edited through the coöperation of The Washington Society of Engineers.

The subjects of the papers and their authors are as follows: Peacefulness and Greatness of the Earliest Engineers, by George H. Johnson; Making Homes in the Desert, by F. H. Newell; Public Water Supply, by George W. Fuller; Transportation, by A. W. Johnston; Some Notable Masonry Bridges, by Henry S. Jacoby; Measurement of Stream Flow by the United States Geological Survey, by John C. Hoyt; Recent Developments in Naval Architecture, by Charles F. Gross.

A nominal charge of 25c. is made to cover part of the printing cost, and the book may be had by addressing the society at the Chamber of Commerce Building, Cleveland, Ohio.

Miscellaneous News

Lightning Burns Up Generator—During an electric storm recently at Hillsboro, Ill., a bolt of lightning struck an electric pole near the power house, sending a heavy charge of electricity into one of the big generators in the plant and damaging it badly. After the accident all the towns in the northern part of the county were without electricity for about half an hour until another generator was connected and started working. The company now has no extra generator, and should another accident happen things would be in a serious condition. The damages will cost about $6000 to repair.

Pasadena (Calif.) Is Urged To Buy Edison Power System—Recommendations by the general manager of the Pasadena municipal lighting company have been made to the city commissioners for the purchase of the local distributing system of the Southern California Edison Co. The plan under consideration also provides that the municipality purchase electrical energy at wholesale rates from the same company for a period of thirty years. Under the terms of the proposed agreement Pasadena will take a two-year lease on the distributing system of the Edison company, with a view to purchasing it at the end of that time for $500,714.79. If the deal is effected, the steam plant will be shut down and used only as needed. Under the terms of the proposed contract, Pasadena would pay rental to the Edison Co. in an amount equal to 8 per cent. per annum of the agreed purchase price to be held by the city as depreciation reserve. The purchase of the Edison system will mean the end of a fight that has been waged for ten years by the city and the corporation.

Personals

J. B. Laird, until recently connected with the Moore Steam Turbine Corp., Wellsville, N. Y., has resigned his position with that concern to go into the machine-tool business.

Prof. Frederick L. Pryor is now dean of the senior class of the department of electrical engineering, Stevens Institute, Hoboken, N. J., in the vacancy caused by the death of Prof. Albert F. Ganz.

Louis A. Hazeltine, formerly assistant professor of electrical engineering at Stevens Institute of Technology, Hoboken, N. J., is now acting professor in the vacancy caused by the death of Prof. Albert F. Ganz.

Engineering Affairs

The Philadelphia Section of the American Society of Mechanical Engineers will hold a joint metting with the Engineers' Club at Witherspoon Hall on Oct. 23. Homer L. Ferguson, president and general manager, Newport News Shipbuilding and Dry Dock Co., will talk on "The War's Effect on Merchant Shipbuilding."

The New Jersey Board of Boiler Rules, at a meeting held in Newark on Sept. 27, adopted the A. S. M. E. Boiler Code for new installations of power boilers and heating boilers, to go into effect Nov. 1, 1917. Provision is to be made by the board for special consideration of boiler contracts and constructions entered upon before that date. The board has held a number of public hearings and at its next meeting is expected to take final action in the adoption of a code for regulation of existing boiler installations.

The Combined Councils of the Universal Craftsmen Council of Engineers of Greater New York held its thirteenth annual entertainment and ball at Maennerchor Hall, on Saturday, Sept. 29. Dancing was the principal feature of enjoyment. A vaudeville entertainment was given at intervals between the dances, and a pleasant night was spent. Frank Martin, of Jenkins Bros., was the floor director. The officers of the combination include E. R. Wallace, chairman; William Jobson, vice chairman; Oscar Paul, recording secretary; J. W. Matthews, financial secretary; Charles Knudson, treasurer.

Business Items

Neiler, Rich & Co. have been selected as supervising engineers in charge of the heating for Camp Custer, cantonment at Battle Creek, Mich. Both Mr. Neiler and Mr. Rich have been on the ground, and the latter will be permanently located there until the completion of the work.

The Poole Engineering and Machine Co., of Baltimore, Md., has recently opened branch offices in Minneapolis and Pittsburgh. The Minneapolis office is at 716 McKnight Building, in charge of R. L. Lunt and the Pittsburgh office at 433 Union Arcade, in charge of J. P. Flippen.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Oct. 6, 1917	One Year Ago	Oct. 6, 1917	One Year Ago
Buckwheat ..	$4.98—5.20	$2.05—3.20	$7.10—7.35	$3.25—3.50
Rice	4.40—4.65	2.50—2.65	6.65—6.90	2.70—2.95
Boiler	.....	.....	.....	.....
Barley	3.90—4.15	2.20—2.35	6.15—6.40	2.35—2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Oct. 6, 1917	One Year Ago	Oct. 6, 1917	One Year Ago
Clearfields ...	$2.42—3.47	$1.15—1.75	.....	$4.25—5.00
Cambrias and Somersets...	2.42—3.47	1.45—1.90	.....	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $4, as compared with $2.85—2.90 a year ago; on cars Boston price is $8.50—8.75.
*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Oct. 6, 1917	One Year Ago	Oct. 6, 1917	One Year Ago
Buckwheat ..	$3.95—4.05	$2.75	$5.10—5.30	$2.75—3.00
Rice	3.40—3.60	2.20	3.80—4.10	2.20—2.25
Barley	2.90—3.15	1.95	3.00—3.30	1.95—2.00

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	F.o.b. N. Y. Harbor	Mine
Pennsylvania	$3.65	$2.00
Maryland	3.65	2.00
West Virginia (short rate)	3.65	2.00

Based on Government price of $2 per ton at mine.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Oct. 6, 1917	One Year Ago	Oct. 6, 1917	One Year Ago
Buckwheat ...	$2.90	$1.65	$3.80	$2.55
Rice	2.40	1.00	3.40	1.90
Boiler	2.20	.90	3.30	1.80
Barley	1.90	.75	2.15	1.65

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Oct. 6, 1917	One Year Ago
Slack	$3.00—3.25	$1.75—2.00
Mine-run	3.00—3.25	2.10—3.30
¾-in.	3.50—3.75	2.20—2.30

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump ..	$2.20	$2.20	$2.40	$2.20	$2.20
Lump	2.20	2.20	2.40	2.20	2.20
Egg	2.20	2.20	2.40	2.20	2.20
Nut	2.20	2.20	....	2.20	2.20
No. 1 nut....	2.20	2.20	....	2.20	2.20
No. 2 nut....	2.20	2.20	....	2.20	2.20
No. 3 nut....	2.20	2.20	....	....	....
No. 1 washed.	2.20	2.20	....	....	....
No. 2 washed.	2.20	2.20	....	....	....
Mine-run	1.95	1.95	2.15	1.95	1.95
Screenings	1.70	1.70	1.90	1.75	1.70

Hocking lump, $2.60; splint lump, $2.40.

Northern Illinois thin vein—Prepared sizes, $2.65; mine-run, $2.40; screenings, $2.15.

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Oct. 6, 1917	One Year Ago	Oct. 6, 1917	One Year Ago	Oct. 6, 1917	One Year Ago
6-in. lump ..	$2.35	$2.00	$2.35*	$1.75	$2.35	$1.65
2-in. lump...	2.35	2.00	2.35*	1.75	2.35	1.40
Steam egg...	2.35	2.00	2.35*	1.75	2.35	1.40
Mine-run ...	2.10	1.25	2.10*	1.25	2.10	1.15
No. 1 nut..	2.35	2.00	2.35*	1.75	2.35	1.40
2-in. screen.	1.85	.90	1.85*	.85	1.85	.80
No. 5 washed	1.85	.80	1.85*	.85	1.85	.75

*Strike.
Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Lump and Nut	Slack and Screenings
Big Seam	$1.90	$2.15	$1.65
Pratt, Jagger, Corona....	2.15	2.40	1.90
Black Creek, Cahaba ...	2.40	2.65	2.15

Government figures.

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ariz., Yuma—The Southern Sierras Power Co. plans to extend its electric light and power line from here to Ajo.

Ind., Elkhart—The Indiana & Michigan Electric Co., 220 Colfax Ave., South Bend, who recently purchased the electric plant at Ligonier, plans to erect an electric transmission line from here to Ligonier. F. P. Ohmer, South Bend, Ch. Engr.

Kan., Garfield—City Commissioners plan an election soon to vote on the proposition to establish an electric lighting plant.

Kan., Sharon Springs—City plans to issue $15,000 in bonds for electrical improvements.

Md., Baltimore—The Maryland Chemical Co., Colonel Ave., has had plans prepared for the erection of a new power plant in connection with its new factory. Estimated cost, $30,000.

Mass., Worcester—The Worcester Electric Light Co. plans to erect a transformer station at the rear of Grafton St. and has already secured a permit for same. Estimated cost, $30,000. E. R. Seed, Engr.

Mo., Kansas City—The Kansas City Railways Co., 3032-34 Montgall St., has been granted a permit and will build a 1-story, power sub-station. Estimated cost, $16,000.

Mont., Troy—Wm. B. McDonald of Troy has been granted a franchise by the City Council for the installation of an electric lighting plant.

Neb., Ord—City Sept. 11 voted favorably on a $30,000 bond issue for an electric-light plant. O. P. Cromwell, City Clk. Noted Aug. 28.

Neb., Pender—City passed a resolution to issue $16,500 in bonds for an electric-lighting plant. Noted July 17.

N. J., Perth Amboy—The Lehigh Valley Railroad, New York, has had plans prepared for a 1-story, 50 x 100-ft. power house at its local plant. Estimated cost, $40,000. G. T. Hand, Ch. Engr.

N. Y., Groton—The Groton Electric Co., recently incorporated with a capital stock of $20,000, plans to build and operate an electric generating plant and distribution system for service here. J. B. Carey, O. E. Wasser and I. J. Magee, 622 West 113th St., New York City, are the incorporators.

N. Y., New York—The Interborough Rapid Transit Co., 165 Broadway, plans to build a substation at East 139th St., to serve the Bronx division of the Lexington Ave. subway. G. H. Pegram, 165 Bway., Ch. Engr.

Okla., Miami—City will hold an election Oct. 16 to vote on $45,000 bond issue for electric light improvements.

Penn., Glen Rock—The Ebert Furniture Co. plans to build a new power plant in connection with its new factory.

Penn., McKees Rocks—The Pittsburgh Railways, 435 6th Ave., Pittsburgh, plans to erect a new sub-station at Island Ave. and Poquet St., here. P. Uhlenhart, Jr., Ch. Engr.

Penn., Sunbury—The Borough Council is having plans prepared for an electric lighting plant here.

Penn., Wormleysburg—The Valley Railways, Lemoyne, is planning to build a new power plant here. A. S. Bentz, Lemoyne, Ch. Engr.

Tex., Sinton—The municipal electric light plant, recently destroyed by fire, will be rebuilt and new equipment, including a new engine, generator, etc., installed.

Va., Norfolk—The Virginia Railway & Power Co. plans to build a new 1-story, brick and concrete sub-station. J. P. Keeny, Ch. Engr.

Wash., White Salmon—Right of way has been secured by the Northwestern Electric Co., Pittock Block, Portland, Ore., for the construction of a large hydro-electric plant on the White Salmon River, between here and Underwood. Estimated cost, $400,000. B. C. Condit, Ch. Engr.

W. Va., Sevy—The Greenbrier Colliery Co. plans to install an electric power plant. Estimated cost, $40,000. J. Wade Bell is Mgr.

Wis., Kiel—The Kiel Woodenware Co. plans to build a power plant addition and has retained T. S. Watson, Arch., Majestic Bldg., Milwaukee, to prepare the plans. Steam generating and electrical equipment will be required. Estimated cost, $20,000.

Alta., Lethbridge—City Council will purchase a new steam turbine and generator immediately in order to provide power for the increased load. Estimated cost, $50,000. A. Freeman, Comr.

Ont., Brantford—Town Commissioners have authorized the Hydro-Electric Power Comn., Toronto, to do the engineering connected with the remodeling and extending of the electrical distribution system which it recently purchased from the Western Counties Electric Co.

Ont., Toronto—Town Council plans to purchase electrical transmission equipment, motor-driven pumps, etc. D. C. Davis, Clk.

Ont., Toronto—The Hosmer Stamping and Die Works, Ltd., 831 Dundas St., is in the market for a power press, etc.

Que., Metabetchouan—Plans are being prepared by J. A. Claveau, Engr., Chicoutimi, for a new hydro-electric plant for Eugene Gagne. Estimated cost, $40,000.